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ABSTRACT

This monograph examines a collection of empirical evaluation studies, each of which compares two or more instructional practices, techniques, or systems for teaching a particular subject or curriculum in terms of one or more quantitative indices of instructional productivity, e.g., teaching effectiveness (pupil performance), and cost factors or both, and reports large between-group differences. Collectively the comparisons made in in the study identify 125 instructional treatments for which one or more indices of productivity was double or more than double that obtained for a comparison treatment or treatments. Categories of teaching methods and/or teaching systems include: (1) conventional instruction; (2) conventional teaching; (3) augmented conventional teaching; (4) conventional tutoring as supplement to conventional teaching; (5) content modification in conventional teaching; (6) procedural modifications of conventional teaching; (7) programmed learning; (8) programmed teaching including programmed tutoring; (9) partially programmed teaching; and (10) performance-based instructional design. The collection of 125 exhibits is appended, each summarized in terms of the source references. Brief descriptions are presented of the subject or subjects taught, the experimental and comparison treatments, the measures of productivity, and the results obtained in the comparisons. (JD)

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IMPROVING THE PRODUCTIVITY OF TEACHING: 125 EXHIBITS

By Douglas G. Ellson

RPR ≥ 2

A CEDR Monograph
Phi Delta Kappa

SP028739

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IMPROVING THE PRODUCTIVITY OF TEACHING

125 Exhibits

by

Douglas G. Ellson

A Publication of Phi Delta Kappa's
Center on Evaluation, Development and Research
Bloomington, Indiana

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Table of Contents

Foreword vii
Improving the Productivity of Teaching 1
A Methodological Consideration 2
The Collection 2
  Table 1 3
The Categories 4
  Conventional Instruction (CI) 4
  Conventional Teaching (CT) 4
  Augmented Conventional Teaching (ACT) 4
  Conventional Tutoring as Supplement to Conventional Teaching (CtCT) 6
  Content Modification in Conventional Teaching (CMCT) 6
  Procedural Modifications of Conventional Teaching (PMCT) 7
  Programmed Learning (PL) 7
  Programmed Teaching (PT) Including Programmed Tutoring (Pt) 9
  Partially Programmed Teaching (PPT) 10
  Performance-Based Instructional Design (PBID) 13
Instructional Costs 15
  Table 2 18
An Incidental Finding 22
Summary 22
Overview 23
Appendix I 27
  Table 3 28
  CT Exhibits 1-8 29
  ACT Exhibits 9-16 37
  CtCT Exhibits 17-23 47
  CMCT Exhibits 24-30 55
  PMCT Exhibits 31-32 63
  PL Exhibits 33-75 67
  PT and Pt Exhibits 76-104 85
  PPT Exhibits 105-120 111
  PBID Exhibits 121-125 115
  References 123

Foreword

For several years the American public has been calling for fundamental changes in the way education conducts its business. Witness the proliferation of reports from national study commissions, starting with *A Nation at Risk* in 1983 and continuing through more than 20 other reports to the National Governors Association Report in August 1986. State legislatures in almost every state have passed laws mandating major changes in the way we judge teacher effectiveness and productivity. Several states have limited funding to education through public referendums with the clear implication that educational programs must become more cost-efficient and productive before school districts will again find a sympathetic public purse. The legislatures have introduced their "solutions" in the form of tougher teacher certification standards, teacher testing, career ladders, merit pay, reduced teacher-student ratios, and others.

With some rare exceptions, professional educators have been unresponsive to the messages sent by the greater American community. Many education administrators apparently believe that their traditional methods of interacting with the public will continue to succeed. These traditional strategies are deeply rooted in high-level bargaining and negotiating skills, political manipulation, and compromise – skills that the American public no longer seems to value.

The American public clearly wants basic changes in the way children are taught and schools are administered. We can now meet that challenge in large measure through greater use of research in our decision making. Through research and data-based decision making, we can now develop and put into practice instructional programs, techniques, and strategies that have proven value. This book, which reports 125 studies of proven instructional practices, furnishes ample evidence that cost-effective educational programs are not only available, many of them have been available for years. Most of these studies have been ignored, however, by the old-style decision makers in education. It is clear that the education establishment needs to change its attitudes and decision-making style, or the public might demand that we change our leaders.

Douglas Ellson's work, accumulated over a 20-year period, provides compelling evidence that educators can implement more productive and cost-effective teaching techniques and strategies. This monograph also provides the beginnings of an educational taxonomy. It clearly identifies variations on a particularly effective instructional technique – programmed teaching and learning – that can help to restore the productivity of America's schools.

Larry W. Barber
Director, Center on Evaluation,
Development, and Research
Phi Delta Kappa

RPR $\geq$ 2 Criterion

Relative Productivity Ratio is equal to or greater than 2

Improving the Productivity of Teaching

The purpose of this monograph is to call attention to a number of comparative evaluations of teaching procedures whose results can help to solve a major problem in American education: low teaching productivity.

The National Commission on Excellence in Education, in *A Nation at Risk* (64), enumerated many quantitative indications that the American educational system is less productive than it was in the fairly recent past, and is less productive than any of its counterparts in other industrialized nations. Further, the commission said that our schools are not satisfying the needs of today's technological society and, unless radical changes occur, will not do so for the increasingly technological society that is predicted for the future. The commission called particular attention to problems in teaching science, mathematics, and other "hard" subjects, including technical fields and foreign languages.

The commission proposed five general solutions and offered several specific recommendations within each solution. Summarized, the five general proposals were:

1. Refine and change curricular emphases – i.e., *what* is taught – to better meet the needs of a technological and small-world society.
2. Raise the expectations and standards of our educational system, paying particular attention to the evaluation of student achievement, textbooks, and other instructional materials.
3. Increase the daily and annual time-on-task of students.
4. Increase the quality, competence, morale, and number of professionally qualified teachers and add nonprofessionals who are specialists in critical subject areas.
5. Hold educators and elected officials responsible for the leadership necessary to apply these remedies and hold both citizens and government responsible for the fiscal support that educators will need to bring them about.

One cannot quarrel with these recommendations. There is no doubt that, if they are carried out, the problems addressed in *A Nation at Risk* will be ameliorated to some extent. But in the light of what follows, it would appear that there are two important omissions in the list. Except for the general recommendation to increase the time students spend on their studies in school and out, there is no recommendation concerning the *how* of teaching – i.e., the methods, techniques, or management of teaching – and almost no mention of the potential contribution of research or research and development. These omissions would perhaps be justified if it were true that the only way to improve the technique of teaching is to improve teachers by administrative means, e.g., by improving their salaries, selection, training, morale, etc. But examination of research on teaching methods reveals that this is not true. Improving teachers can improve the productivity of teaching, to be sure, and in many situations it may be the quickest or best way, but it is not the only way.

The omissions mentioned here may be traced to what N. L. Gage, in a 1968 article in the *Phi Delta Kappan* titled "Can Science Contribute to the Art of Teaching?" (35), described as a "pessimistic" view, accompanied by a "disparaging style in appraising research results [that] has had a great vogue [among educators]." He summarized this pessimistic view:

> [T]he major generalization to be drawn from research is that variations in teaching and educational practice do not make any consistent, significant, or practical difference.[1]

This view, taken literally, is clearly false. It is contradicted by common sense, by the evidence that learning and memory are affected by environmental conditions at the time they take place, and more directly and explicitly by data in the research reports summarized below. However, if Gage's summary of the pessimists' view were stated differently, to say, for example, that research-based knowledge of the effects of teaching practices *are not being used* in ways that make a consistent, significant, or practical difference, it would be true. It is true in the sense that the results of research on the effects of variations in teaching and educational practice are seldom applied. A colleague once said, "We know how to teach better than we teach."

Gage presented several examples of the kinds of information that have been cited to support the pessimistic view, including one book (93) that purports to prove theoretically that teaching practices can not have a significant effect on student achievement or "growth"!

Gage then went on to say, more optimistically:

> . . . more adequate financial support is providing better organizations and facilities for educational research and development. The faith persists that educationally significant differences can be consistently produced in the future as new intellectual and material resources are brought to bear on educational problems.[2]

The remainder of this monograph examines a relatively large collection of evaluative research studies – largely ignored by school and university establishments – that report large differences in one or more quantitative indices of teaching productivity obtained when two methods of teaching and/or teaching management systems were compared. In each comparison of two techniques, the common dependent variable is *relative* productivity or cost, i.e., the ratio of the effects of an experimental treatment and a comparison treatment that provides a baseline. The collection was begun a few years before the appearance of Gage's article predicting such differences, and soon became a hobby. It now contains some 75 papers, each of which compares one or more pairs of teaching methods or management practices and reports at least one difference in teaching productivity – e.g., teaching effectiveness, cost, efficiency, or cost-effectiveness – that can be considered large enough to be "educationally significant." Very early, to simplify and objectify the search process, "large enough" was defined quantitatively as an improvement of 100% or more, i.e., as a difference represented by a relative productivity ratio (RPR) of 2.0 or more. Together, the 75 papers include evaluation data for a total of 125 teaching techniques which satisfied the RPR ≥ 2 criterion for one or more indices of productivity, e.g., teaching effectiveness, instructional time, cost, efficiency, or cost-effectiveness.

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[1] N. L. Gage, "Can Science Contribute To the Art of Teaching?" *Phi Delta Kappan*, March 1968, p. 400. Gage was summarizing a pessimistic view among some writers of the day, notably that of J. M. Stephens in *The Process of Schooling*, Holt, Rinehart & Winston, 1967.

[2] Ibid., p. 403.

A Methodological Consideration

In scientific reviews of empirical research papers it is customary to be carefully critical of research method. The reviewer is expected to identify any methodological error in experimental or logical procedures, described or implied, that suggests a non-negligible *possibility* that the reported data or conclusions could be false. The reviewer is also expected to mention any aspect of reporting – e.g., incomplete reporting of procedures, the non-negligible presence of typographical errors, etc. – which suggests the same possibility. Such errors are so common that they have been given a name – Type I errors, those that can result in the acceptance of false statements.

Because of its technological rather than scientific orientation, this monograph is more concerned with the avoidance of Type II errors, that is, the rejection of possibly true statements, especially when they are rejected because they are possibly false. It is, therefore, not a critical review; its purpose is primarily technological rather than scientific. It was written to call attention to papers that individually and collectively contain promising leads toward solutions of practical educational problems, solutions that many people consider to be critical to the point that if they are not soon found and applied, the nation's future or its security will be at risk. In such a situation it is not appropriate to reject or ignore methodologically imperfect research from the start on the ground that there is a *possibility* that the data or the conclusions and implications derived from them are false. If one is attempting to solve an important problem, he welcomes information that promises solutions unless or until he is more than reasonably certain that the information is false or misleading. A technologist may, quite appropriately, be more interested in a slight possibility that a report is true than in a strong possibility that it is false, especially at the beginning of a research and development process. At the stage when even possible solutions appear to be rare, brainstorming, a technique designed to avoid Type II errors, is an appropriate component of research and development.

The Collection

The collection of 125 exhibits is summarized in Appendix I in the form of a systematic annotated bibliography arranged alphabetically by author or project name within more or less arbitrary major categories of methods or systems of instruction. Each exhibit represents one method or technique of teaching that has satisfied the RPR ≥ 2 criterion in one or more experimental comparisons with at least one other. In each exhibit the information concerning the technique is summarized in terms of the source reference or references and brief descriptions of the subject or subjects taught, the experimental and comparison treatments, the measures of productivity, and the results obtained in the comparisons which satisfied the criterion. RPRs are reported only for techniques that are shown to be superior in one or more comparisons, and with a few exceptions, only RPRs equal to or greater than 2 are shown. For all RPRs derived from comparisons of indices for which an RPR of less than 1.0 would characterize the superior method – e.g., indices of cost, proportion of failures, or assignments to special education – the RPR is inverted; that is, its reciprocal is reported.

Table 1 indicates the number of cases satisfying the RPR ≥ 2 criterion in each category. The categories were chosen and techniques were assigned to them – of necessity, in some cases, somewhat arbitrarily – primarily to emphasize characteristics of methods that appeared to be important to their authors or to have practical significance for the solution of educational problems. The categories are not mutually exclusive; most techniques could have been assigned to more than one.

There were 32 examples of the general category, conventional instruction (CI), that satisfied the RPR ≥ 2 criterion, 26% of the total in the collection. Of the 32, eight were examples of conventional teaching (CT). In five of these cases the CT procedure satisfied the criterion in comparisons with another CT procedure; most of these were control procedures. In two cases the criterion was satisfied in comparisons between two experimental variants of CT, and in one case a form of CT was found to be twice as productive as a form of programmed learning. The remaining 24 examples of CI were experimental/control comparisons in which the experimental treatment that satisfied the RPR ≥ 2 criterion was a variant of CT.

These variants of CT included four types: 1) In eight examples the defining common feature was a major augmentation of CT (ACT). The augmentation consisted of the addition or elaboration of a number of conventional components of CT made possible by the provision of special funds, personnel, teaching materials, physical facilities, etc., that are not generally available in public schools. 2) In seven procedures CT was supplemented with conventional teacher-

Table 1

Teaching Techniques that Satisfy the RPR ≥ 2 Criterion, by Category*

Categories	*Abbreviations*	*N*	*Totals*	*%*
I. Conventional Instruction: Conventional Procedures and Variants	**CI**			
Conventional Teaching	CT	8		
Augmented Conventional Teaching	ACT	8		
Conventional Teaching plus Conventional Tutoring	CtCT	7		
Content Modification of Conventional Teaching	CMCT	7		
Procedure Modification of Conventional Teaching	PMCT	2		
Total CI		32	32	26%
II. Programmed and Partially Programmed Instruction	**PI**			
Programmed Learning	PL	43		
Programmed Teaching, including Programmed Tutoring (Pt)	PT	29		
Partially Programmed Teaching	PPT	16		
Total PI		88	88	70%
III. Performance-Based Instructional Design	**PBID**			
Total PBID		5	5	4%
TOTAL EXHIBITS		125	125	100%

*RPR ≥ 2: Relative Productivity Ratio is equal to or greater than 2.

directed tutoring by students or nonprofessional personnel (CtCT). 3) Seven other procedures (or, as they are generally called, "methods") specified only special characteristics of the *content* that was taught (CMCT). 4) Finally, there were two relatively simple modifications of conventional teaching *procedure* (PMCT). One of these, Exhibit 32, suggests a potential contribution to the art of teaching defined narrowly as the personal hands-on skill of a teacher. The other, Karnes's Community Integrated Procedure, Exhibit 31, is perhaps better described as a possible contribution to the art of school administration. PMCT, CMCT, and, if tutors are unpaid, CtCT, are distinguished from ACT by the fact that they do not ordinarily require additional resources or paid personnel.

Ninety-three exhibits (74% of the total in the collection) may be described as nonconventional techniques in the sense that none are in common use in general education. All are products of a relatively new sub-profession of education, namely, instructional systems design, which utilizes several relatively new psychotechnologies of teaching. In many cases they also make use of one or more physical technologies of education – such as print, broadcasting, audiovisual equipment, teaching machines, training devices, and computers – as teaching media.

Forty-three of the nonconventional cases (35% of the total number in the collection) are examples of programmed learning (PL), a highly structured self-instructional teaching technology that is often combined with physical forms of educational technology, e.g., books, teaching machines, or computers. Twenty-nine cases (25%) are examples of a more recently developed form of programmed instruction, programmed teaching (PT). In this technology the teaching or tutoring activities of (usually nonprofessional) teachers are specified in detail, ordinarily by printed instructions (programs) similar in function to the instructions that are an integral part of the programs given to the learners in PL. Since the pupils are not required to read the instructions, PT is ordinarily better adapted than PL to the teaching of beginning reading, and for this and other reasons it is better suited to the teaching of young children.

Sixteen cases (13%) are examples of partially programmed teaching (PPT) in which CT and PT techniques are combined to form a third procedure, performance-based instruction.

Five exhibits (4%) have been assigned to a general category, performance-based instructional design (PBID) which is not a teaching technique; it is a procedure for designing teaching techniques of any kind, conventional or programmed. This procedure is routinely used by instructional systems technologists to design programmed instruction, but two exhibits in this category indicate that it can be equally effective when applied to the improvement of existing conventional instruction. It may be recognized as an explicit and detailed form of a technique undoubtedly used by master teachers to improve their teaching skills.

The Categories

Conventional Instruction (CI)

Conventional instruction is a generic name for teaching procedures that are generally acceptable and in common use. Because of the practice, common in educational research reports, of omitting the description or even a name for the method used to teach control or baseline groups, the generic term remains essentially undefined in this monograph. It is not one method, of course; it is many. They differ from each other not only with respect to subject and level taught, but according to various teaching procedures, community features, characteristics of the pupils taught, the background, training, and personality of the teacher, and many other factors.

Conventional Teaching (CT)

For purposes of this review, it will be useful to emphasize one characteristic that seems to be common to all current forms of conventional teaching, and distinguishes them from the less conventional programmed forms of instruction that appeared in the collection. Currently, conventional methods of teaching are teacher-centered to a very high degree. In conventional teaching the teacher, and in the case of conventional tutoring the tutor, is responsible almost entirely for determining *how* the teaching is done. To a lesser extent the teacher or tutor is responsible for choosing texts and other teaching materials and for deciding what is to be taught from or with them, i.e., for choosing curricular and instructional objectives. In the categories of instruction that we have identified as nonconventional – namely, PL, PT (but not PPT), and PBID when applied to the design rather than the improvement of instruction, essentially all decisions concerning both teaching procedures and content are ordinarily made by instructional systems designers rather than by teaching personnel.

Some of the techniques classified as nonconventional are teacher-centered to the extent that the teacher rather than an administrator or the public makes the important decision to use or not to use them. In most applications in schools, a teacher also supervises their use and functions as troubleshooter.

The four categories of conventional instruction that follow – augmented conventional teaching (ACT); conventional teaching supplemented by conventional tutoring (CtCT); special, and sometimes unconventional modifications of conventional content taught by conventional teaching procedures (CMCT); and simple modifications of conventional teaching or management procedures (PMCT) – may be described as variants of CT. With few exceptions, the experimental variants of CT in the collection proved to be more effective than the unmodified or unspecified forms of CT chosen as control treatments.

Augmented Conventional Teaching (ACT)

Augmented conventional teaching (ACT) uses complex methods that incorporate additional resources – funds, paid personnel, special equipment and teaching materials, etc. These resources facilitate the work of teachers who continue to use conventional methods. Facilitation is achieved by increasing instructional time; by increasing individualization; by reducing class size or teaching loads; by enabling teachers to delegate teaching and nonteaching responsibilities to other teachers and/or to professional specialists, non-professional aides, or tutors; by using additional teaching materials and equipment; by content modifications; by increasing the salaries of teachers; by improving the morale, quality, or qualifications of teachers; etc. In some ACT exhibits described below, programmed instruction, probably in the form of PL or PT, is mentioned as a component of the technique. With this exception, ACT might be described as a quantitative modification of conventional teaching. It makes increased use of certain well-known components of conventional teaching that have long been assumed or known to improve teaching effectiveness but are not widely used because of traditionally austere school budgets.

Since differences between ACT methods are at least as great as their similarities, they will be characterized individually below, chiefly by quoting descriptive phrases from their authors:

– The College Bound Project method (Exhibit 11): "intensive instruction in classes of 16 to 20. . .in mathematics and English," "two periods of English," "programmed instruction," "They met. . .individually for counseling aid and in groups for guidance in study and work habits," "library skills," "college students as educational assistants to help provide individual instruction," "supervisors. . .to develop the curriculum. . .and work closely with the teachers and educational assistants," "books," "rich reading experience," "speakers from the fields of higher education and business," "homogeneous grouping," etc.

– The Fernald Method (Exhibit 10): The Fernald School program, considered as a teaching method, is described as "individualization of instruction," "the atmosphere is permissive, but. . .distinguished from license," "broad, individualized instructional program," "specific learning goals established for each child. . .permit the child to experience success in a learning task which has previously provided him with consistent failure," "improvement is positively reinforced," "non-punitive learning environment," "particular effort. . .to exclude. . .kinds of negative reinforcers and criticism which tend to lead to self-devaluation and feelings of incompetence," "videotape recorders," "a video-taped play," "closed circuit television," "wide range of commercial and teacher-made materials," "classrooms are limited to a maximum of 19 students," "the student-to-adult ratio is usually about four to one," "a group of mature and dedicated university students . . . participated in family and social contacts and in various therapeutic and educational programs . . . far beyond that required to meet student needs and obligations."

– The R-3 Programs (Exhibits 14-15): "A motivational program emphasizing student readiness and learning reinforcement through individualized instruction," "individual progress program using contracts based on extensive diagnostic-prescriptive information," "continuous curriculum modification," "parental involvement, home visits and . . . inservice training component," "writing of performance objectives," "heterogeneous grouping," "extended field trips of two or three days," "a curriculum that interrelates reading and mathematics with reinforcement through gaming/simulation," "a wide variety of audiovisual equipment is used – overhead, film and slide projectors, tape recorders, language masters, listening posts, microphones, videotape cameras, monitors, recording consoles, calculators and typewriters," "materials include videotapes of lessons and trips, tape-recorded . . . guest lectures, slides, and films," "a teacher and an instructional aide assigned to a classroom of 20 students," "70% of the classwork is done in an individualized learning situation and the other 30% in small groups of from two to seven students," "regular home visitation by project staff," "dinner meetings for parents, students, and program personnel."

– The Montessori Method (Exhibit 13): Low pupil-teacher ratio, extensive special facilities, equipment and materials designed for pre-academic curriculum. "Education of the senses." A "room for intellectual work" plus "houses . . . adapted for children and not for adults." "Complete equipment for the management of the miniature family," "pleasing artistic pictures which are changed from time to time as circumstances direct." "Motor education." "Sensory education." Oral and aural language and its referents, including material referents of arithmetic as a language. Extensive specialized materials for instruction in each of the three areas.

– The Enriched Curriculum (Institute for Developmental Studies program) (Exhibit 9): Emphasis on "cognitive areas of language, perception, and concept formation, as well as the affective area of self-concept," "individualizing of instruction," "small instructional groups," "the child was allowed to proceed at his own pace," "emphasis . . . on inservice training," "special teaching materials," "high degree of both quantity and quality of (teacher) supervision," "home visits," "parent involvement," "creative dramatics," "language laboratory."

– Diagnostically-Based Curriculum (Exhibit 12): Individualized instruction based on evaluations made by four professional specialists who worked with the teacher in the classroom and provided "diagnostically derived lesson plans," seven professional specialists as consultants, "utilization of each teachable moment," "new concepts . . . demonstrated . . . as well as explained," "concrete reinforcement and/or social approbation," "evaluations of individual children's performance in any activity," "audiovisual aids," "specially painted murals."

– The Success Environment (Exhibit 16): "positive behavior modification," "the teachers adhered to a basic premise of "ignore and praise," that is, they attempted to attend the "reward-suitable behavior while disregarding improper conduct." (throughout the school year); throughout the first day and several days thereafter, "immediate primary reinforcement (M&Ms and hard candy) was paired with praise and token reinforcement contingent upon approximations of desired social conduct." "During the third and fourth months intangible rewards were replaced with activity reinforcers . . . the pupils traded tokens for access . . . to the activity room supervised by the paraprofessional aides . . . five academically oriented interest stations . . . a library station with books, magazines and newspapers; an arts station . . . paints, crayons, etc; a communication station . . . language master, phonograph, and tape recorder; an exploratory station . . . science materials keyed to the instructional program; a games and puzzles station . . . primarily with academically related materials . . . changed at least weekly by paraprofessional aides"; carefully designed training of teachers in behavior modification theory and practice, plus "an experienced behavioral management technician was available at least twice weekly to assist each teacher with current problems in classroom management. Individual inservice sessions concerning curriculum implementation were also conducted weekly by two curriculum coordinators. . . ."

Note similarities between this study and the diagnostically-based curriculum study (Exhibit 12) which may be attributable to the participation of a common author, McCandless.

Results obtained in evaluations of these ACT methods suggest rather convincingly that if the funds necessary to implement them on a large scale were made available the effectiveness of our educational system could be markedly, if not spectacularly, improved. Reported results include the following:

- increases in Stanford-Binet IQs ranging from 15 to 20 points and, compared with conventional at-home treatments, gains in performance on language tests increased by factors as high as 4.2 (Exhibit 12);

- reduction in number of classroom disruptions by a factor of 4.5 and, compared with conventional school instruction, gains in Columbia Mental Maturity Scale IQs by factors as high as 13.8, plus grade equivalent gains on tests of reading and mathematics achievement by factors of 3.2 and 3.4 respectively (Exhibit 16);

- improvement in anxiety scale scores by factors ranging from 2.4 to 9.0, and a six-fold increase in the proportion of students whose performance on academic achievement tests increased by one grade equivalent or more during the year of evaluation (Exhibit 10); and

- gains in Stanford Achievement Test scores in reading, arithmetic computation, and arithmetic concepts, by factors of 2.7, 6.7, and 4.7 respectively (compared with gains calculated from national norms) (Exhibit 11).

If the obvious cost of replicating these ACT methods is ignored, these results suggest that the pessimists are wrong. Excellence in teaching can be approached, if not achieved, in some areas of instruction by appropriate modifications in teaching procedures.

However, if cost is a consideration, it may be pointed out that the categories that follow contain many examples of less costly alternatives that have produced comparable results. Some of these procedures, when embedded in suitable school and classroom management practices and an updated infrastructure, and especially when used on a large scale, promise to cost less than teaching methods now in common use.

Conventional Tutoring as a Supplement to Conventional Teaching (CtCT)

None of the examples of CtCT in the collection used professionally trained teachers as tutors; all used students in cross-age or peer tutoring. Otherwise the examples of tutoring in the collection are fairly representative of conventional tutoring practices within conventional classrooms. Within these limits, CtCT is tutor-centered in the same way that CT is teacher-centered. Outside the classroom, tutors may be fully responsible for teaching objectives, materials, and methods. As CtCT is ordinarily used in schools, instructional objectives and materials are usually specified by the supervising teacher or the institution that the classroom serves. General tutoring procedures are usually controlled by the teacher, but in CtCT the tutor is not given a detailed or formal program to follow and as a consequence must improvise some or all of the teaching method during the course of teaching, and in some cases may improvise teaching materials as well.

Three of the seven studies classified as CtCT presented data on the performance of student tutors as well as tutees. The data indicate that the academic benefit for student (cross age or peer) tutors can be as great or greater than that for the tutees.

In the Youth Teaches Youth (YTY) program evaluated by Cloward (Exhibit 17) tenth- and eleventh-grade students tutored fourth- and fifth-grade pupils in reading. The student tutors were given approximately 68 hours of training before and during a 26-week period of tutoring, in addition to supervision by professional teachers during the tutoring. Each tutor worked after school hours with two tutees – one for four hours per week, the other for two. For tutees, gains in reading performance on the New York Tests of Growth in Reading were statistically significant for the four-hour group only, but the RPR (1.7) did not satisfy the RPR $\geq$ 2 criterion. For the tutors, whose reading achievement was also evaluated, RPR equalled 2.0 for grade-equivalent gains on the Iowa Silent Reading Test and was 6.4 for standard scores on the Iowa comprehension subtest.

In a small-scale study by Morgan and Toy (Exhibit 21), pupils from grades 8 through 12 tutored pupils from grades 2 through 5. Tutors were given much less training, less supervision, and more responsibility for technique than those in the YTY program. In this study, RPRs greater than 2.0 were reported for both tutors and tutees on reading, spelling, and arithmetic subtests of the Wide Range Achievement Test. As in the preceding example, differences in gains as indicated by the values of RPR were greater for tutors than for tutees.

In a third study (Exhibit 18), in which under-achieving ninth-graders tutored fourth-graders in mathematics (fractions), both tutors and tutees gained significantly more than their control groups, but only the difference for the tutees satisfied the RPR $\geq$ 2 criterion. RPR was 2.01 for tutees, 1.97 for tutors.

The four remaining studies in the CtCT category (Exhibits 19, 20, 22, 23) examined tutee data only.

Content Modification in Conventional Teaching (CMCT)

Methods in the content modification (CMCT) category are identified by special characteristics of what is taught – content – rather than how it is taught. They are constructed by specifying a logic or organization of the subject matter that differs from that in common use or a different emphasis given to particular content components. Teaching techniques may be left unchanged or altered only in minor detail as this may be necessary to accommodate special characteristics of content. An example is the substitution of the Initial Teaching Alphabet (ITA) for the standard English alphabet in the teaching of reading. John Downing, the author of the source for Exhibit 25, which compared ITA with standard orthography, says: "In both the experimental and control classes the teachers have been asked not to change their normal methods of teaching but to operate their usual timetables and instructional procedures."

Another clear example of CMCT is Landa's Algorithmization technique (Exhibit 29), in which aspects of Russian grammar were reduced to precisely formulated rules or "algorithms," then taught by conventional techniques. In the evaluation study both algorithmized and standard grammar were taught with traditional procedures. Performance of the two groups was compared on three criterion tests, with differences in favor of the experimental group that are summarized by RPRs of 5.0, 5.11, and 6.6. Landa's use of algorithmization should be contrasted with programmed instruction (see below), in which teaching technique rather than content is algorithmized, but what is taught remains the same.

A most effective example of CMCT is Carter's Language Stimulation method (Exhibit 24). Traditional small-group teaching methods were used to present content that is defined as "the first 40 Daily Lesson plans from the Peabody Language Development Kit." Content is thus loosely programmed or, in Landa's terms, quasi-algorithmized, but technique again is conventional – i.e., it is determined, or improvised, primarily by the teacher. In this exhibit, gains in IQ and psycholinguistic abilities were both markedly increased, by factors of 2.3 to 6.3. Follow-up measures of IQ and reading performance indicated that much of the effect of the 10-week, 33-hour exposure to the language stimulation curriculum was demonstrable six years later.

Other forms of CMCT are often described as different methods, although they differ significantly only in content. Consider, for example, the basal reader and the phonics methods for teaching reading. Both are ordinarily taught by conventional techniques in teaching beginning reading, and teachers who use them ordinarily teach all of the traditional knowledge and skill components of reading: letter names, letter and letter-group sounds, oral reading, and the meanings of words and sentences. They differ chiefly in the relative emphasis given to meaning and to grapheme-phoneme rules and to the order in which content components are presented.

Procedural Modifications of Conventional Teaching (PMCT)

A broad definition of PMCT would include almost all of the other categories of conventional instruction; the exceptions are CT and possibly CMCT. Programmed learning and programmed teaching are also procedural modifications. To avoid this overlap, PMCT has been defined narrowly, as a relatively simple and conventional change in a teacher's skill or practice. So defined, this category included only two examples, and, strictly speaking, only one of these qualifies as a modification of *teaching* practice. The other represents an administrative change.

One example of PMCT is reported in Rosenthal and Jacobson's paper, "Teachers' Expectations: Determinants of Pupils' IQ Gains" (Exhibit 32). This study is unorthodox, and its method could not be applied to the general improvement of teaching without radical alteration, but its results and their implications are clearly of notable educational significance.

The experimental and control subjects in this study, some 620 pupils in grades 1 through 6, enrolled in 17 classrooms averaging 36 pupils each, were given appropriate forms of a standardized, relatively nonverbal measure of intelligence – Flanagan's Test of General Ability (TOGA). This test was incorrectly identified to the teachers as the "Harvard Test of Inflected Acquisition." The teachers were later given the names of approximately 20% of the children in their respective classes and led to believe the false proposition that the scores of these pupils on this " 'test for intellectual blooming' indicated that they would show unusual intellectual gains during the academic year." Actually, the children who were named constituted the experimental group (before attrition due to turnover) and had been chosen randomly from the pre-tested group (the entire school population). Thus, by implication, the teachers were also led to believe the true proposition that the unnamed 80% (who constituted the control group) were not expected to make unusual intellectual gains.

After eight months of instruction by the teachers so indoctrinated, the children were re-tested. Differences in IQ gains for the experimental and control groups, which the authors of the study attributed to "teachers' expectations," were statistically significant for the first and second grades and for all grades combined; mean gains for the first and second grade experimental groups were 27.4 and 16.2 IQ points, respectively. When these gains were compared with gains for the control group, the corresponding RPRs were 2.28 and 2.36.

Considered as an evaluation of teaching methods, this study is unique: The teaching method is not specified for either the experimental or the control group. All that is known with reasonable certainty is that the teaching methods used for members of the two groups were different, and even this must be inferred from other information, including the experimental and control treatments of the teachers and their effects on the performance of the pupils. Despite these "defects," however, this study provides convincing evidence that, contrary to the views of those Gage called pessimists, variations in teaching practice can produce educationally significant differences. By demonstrating some of the consequences when teachers hold optimistic or pessimistic views of the learning potential of their pupils, the results of this study indicate that a teacher's attitude can be an important determiner of a pupil's performance. This evidence may be criticized, but it should not be ignored by those concerned with the improvement of teaching.

Because of the unorthodox nature and the potential importance of the Rosenthal and Jacobson study, it should be added that several studies using similar procedures have obtained similar results, but others have not. Further research is required to determine the practicable conditions necessary to produce the expectancy effect – and perhaps to use it to benefit pupils.

The second example of PMCT is the "Community-Integrated" procedure evaluated by Karnes (Exhibit 31, see also Exhibit 93). Disadvantaged children were taught conventionally in socioeconomically integrated classes. "Presence of an advanced peer language model" was assumed to be the "central" experimental variable. Four RPRs, ranging from 2.06 to 8.00, satisfied the RPR $\geq$ 2 criterion. This example is perhaps better described as "miscellaneous"; it is more of an administrative procedure than a modification of a teaching procedure.

Programmed Learning (PL)

Broadly defined, programmed learning (PL) is any form of self-instruction in which students' interactions with teaching materials – e.g., samples of the natural world or transformations of it such as those found in laboratories, shops, pictures, books, computers, and human behavior – are prescribed by detailed instructions or "programs" designed to produce or facilitate learning. The design of the program and the selection or design of the teaching materials may be governed by scientific principles of learning, by other knowledge or principles, by the art of teaching, by instructional objectives, or by any combination of these.

In practice, however, PL is defined more narrowly. The term "programmed learning" commonly refers to relatively simple forms of self-instruction, first proposed systematically by B. F. Skinner (87), in which procedures specified in the programs are based primarily on the concepts of positive reinforcement, operant conditioning, and informational feedback. In these programs, although it is not required by these concepts, complex or extended subject matter is ordinarily reduced to a sequence of small units or "frames," each of which 1) poses a problem or task that represents an explicitly defined instructional objective, e.g., a question to be answered or some other task to be performed, and 2) provides informational feedback that enables a learner to evaluate the adequacy of his or her response in relation to the objective. If the learner judges his or her response to be adequate, this feedback is assumed to provide positive reinforcement; if not, the feedback presumably facilitates a more adequate response to the same or similar subsequent frames or other test situations presented later. Described in these relatively nontheoretical terms, PL can be seen to have much in common with the recitation method, a teaching procedure widely used in conventional classrooms.

Insofar as the instructions that the student follows and other information that the student is given are presented in print, the use of PL is largely limited to pupils who can read. The use of programmed learning (PL) for illiterates is rare; PL has been used, but seldom, to teach beginning reading to young children.

Experience gained in the 60 years since PL was first developed (by Pressey) suggests that it may be thought of as a special form of self-instruction which enables those who can read, but are not fully literate, to learn more easily from print. As a means of instruction it is generally more tolerant of inadequate literacy than are most conventional books. Its use probably functions to increase higher literacy.

Programmed learning was first systematically developed for instructional purposes in 1926. A catalog listing over 2,000 programs, chiefly of United States and British origin, and representing a wide sampling of academic and vocational school curricular areas, from pre-primary to university levels, was published in 1972 (9). These programs have not been widely used in U.S. schools. However, PL has been adopted as a major technique for industrial and military training, perhaps because highly specific curricular requirements, a shortage of teachers with suitable technical training, irregular enrollment times, and other practical constraints rule out many conventional solutions to training problems.

The Open University of Great Britain (Exhibit 58) provides an exceptional but important example of the academic application of PL. The PL technology used by the Open University satisfies the narrow definition of PL, but it employs very large rather than small frames and in other ways more closely approximates conventional teaching procedures. In the Open University plan, the basic PL instruction is supplemented to a limited extent by several conventional teaching procedures – lectures, demonstrations, laboratories, tutoring, etc. – that provide the student with a variety of experiences and opportunities to practice skills not easily acquired exclusively from books, programmed or unprogrammed. The Open University is a full-scale production model of a system for general education at the university level that utilizes programmed learning from books for approximately 85% of a student's instructional time. At the same time, it is an experiment that provides a large scale evaluation of that system. Instituted in 1971 with about 25,000 students, the Open University has since more than tripled its initial enrollment, and its success is further suggested by the organization of other universities on similar plans in other countries.

The Open University is the first working model of Thomas Carlyle's "true university." Amost its entire administrative and pedagogical structure is designed to provide an effective system for self-instruction from a collection of books. It exhibits for the first time what Carlyle (10) predicted in 1841:

> If you wanted to know what Abelard knew, you must go and listen to Abelard . . . Such, I conceive, was the origin of Universities.
>
> It is clear, however, that with this simple circumstance, facility of getting Books, the whole conditions of the business from top to bottom were changed. Once invent Printing, you metamorphosed all Universities, or superseded them! The Teacher need not now to gather men personally round him, that he might *speak* to them what he knew; print it in a Book and all learners far and wide, for a trifle, had it each at his own fireside, much more effectually to learn it! . . . If we think of it, all that a University, or final highest School can do for us, is still what the first School began doing – teach us to *read*. We learn to *read*, in letters of all manner of Books. But the place where we are to get knowledge, even theoretic knowledge, is in the books themselves! It depends on what we read, after all manner of Professors have done their best for us. The true University of these days is a Collection of Books.[3]

The curriculum of the Open University is as varied as that of most British universities, but its students are more varied. They include young and old, the employed and the unemployed, housewives, the handicapped, the poor, prisoners, and others who are confined to the vicinity of their own "firesides" for social, physical, or financial reasons. Many of these students would not have been considered acceptable by other British universities. However, the graduates of the Open University are judged to be the equivalent of students of other British universities and are accepted by them as graduate students. Costs per student to the British government, which funds the university, are approximately one-third those for other British universities, and costs to the student are approximately one-fifth.

There is a strong possibility that costs for replicating the Open University plan are significantly overestimated here and in the source. They were derived from the Open University budget totals, which presumably included salaries and support for the faculty and technical staff who developed the instructional programs, as an expense. Other universities that followed the Open University plan and used the teaching materials developed by the Open University would not bear this expense, or would bear only a part of it. The amount would depend on the factor of scale, or whether students or the university purchased the materials.

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[3] Thomas Carlyle, "The Hero as Man of Letters," in *On Heroes, Hero-Worship, and the Heroic in History* (London: Chapman and Hall, 1897).

The primary teaching method of the Open University system is properly classified as programmed learning – i.e., programmed self-instruction. However, the Open University applications of PL technology differ radically from the more common small-frame forms. The instructional paradigm is the same, but the "frames" are typically much larger. The Open University form of PL in practice bears a closer resemblance to a programmed library than to classroom recitations, which provide a model for the more familiar forms of PL.

Apparently, the teaching effectiveness of the large-frame form of PL used in the Open University plan is, so far, not equal to that reported for the more common small-frame forms. It appears to be no better than that of conventional, more Abelardian models of university teaching (RPR = 1). With further research and development, this ratio can presumably be increased, e.g., by use, or further use, of PBID (see below). However, even without improvement in teaching effectiveness, Open University remains a model for economy and cost-effectiveness in university-level and, perhaps, secondary-level instruction.

Seen from the point of view of its funding agency, the cost-effectiveness of the Open University system now appears to be approximately three times that of conventional university systems. But from the point of view of the student and that of a society at risk, because it has difficulty employing those with much less than a university education, the more important index of cost-effectiveness may be the personal one, which for the Open University system has a value of five. It is the *personal* cost, or the ratio of teaching effectiveness to personal cost, that determines whether most potential students can or will obtain a university education.

Programmed Teaching (PT)

Broadly defined, programmed teaching (PT), which includes programmed group teaching (PGT) and programmed tutoring (Pt), is a method of teaching (in principle, any method) in which the interactions of teacher, pupil, and teaching materials are specified in detail. Teaching content is specified by tightly prescribed materials and content programs, teaching procedures by complete and unambiguous operational programs. Instructions are presented in printed form to a teacher or tutor, who relays them orally to the pupil. As is the case for PL, there is also a more common narrow definition of PT, which applies only to forms that make obvious use of or are explicitly derived from scientific learning principles such as association, differential reinforcement, operant conditioning, concept formation, and informational feedback, etc.

To one who observes PT in practice and does not know that the teacher or tutor is following a tightly structured program, teacher-pupil interactions in PT are not noticeably different from those in traditional forms of the classroom recitation method or (if what is being taught is complex or not primarily verbal), the project method. But when the programs that structure the teachers' activities are examined, they are found to differ only in detail from those of PL. As in PL, programs for a single frame (called an "item" in PT) typically begin with the presentation of a problem-question or a request for the pupil to perform a verbal or nonverbal task. What follows is performance-based; it depends on the pupil's response. An acceptable response is ordinarily followed by praise from the teacher or by some other indication that the response was correct (reinforcement). Again as in PL, an unacceptable response is followed by teaching, i.e., presentation of information designed to facilitate a correct response to the same or related item-tasks. For a simple element-task, the teaching may consist of the demonstration of an acceptable response, e.g., a correct answer to a simple question. For a complex task, the teacher may demonstrate, describe, explain, or otherwise present all or parts of the task that the pupil failed to perform adequately. Finally, the pupil may be given another opportunity to perform the total item-task that he or she initially failed. The response to this second opportunity to respond is very likely to succeed because of the teaching that immediately preceded it. If the pupil succeeds, the success is recognized or rewarded; if not, the failure is ordinarily ignored and the program proceeds to the next item. This re-presentation procedure maximizes the opportunities for success and reinforcement on each item.

One of the useful functions of PT is to enable those who lack special training in teaching to teach well. PT procedures are designed to match the characteristics of teachers as well as those of pupils. If the potential programmed teachers or tutors are not professional teachers but are specialists in the subject area to be taught, the program may be designed to enable them to transmit what they know or can do. If the teacher or tutor is not expected to be an expert in the subject matter to be taught, the program can be designed so that the necessary knowledge is carried by teaching materials.

One of the first PT programs to satisfy the RPR ≥ 2 criterion, the Bell System First Aid and Personal Safety Course (Exhibit 94), was designed to improve an existing course ordinarily taught by persons who were qualified in first aid but not in teaching. In evaluating this course, the objectives of both experimental and control courses were defined as the ability to meet the Red Cross requirements for the standard first aid certificate, as these are represented in the Red Cross First Aid Handbook. Mean gain on a criterion test by pupils taught in the programmed course was nearly five times that for the conventionally taught control group (RPR = 4.74); there was no overlap between gain scores for the two groups. Instructional time for the standard conventional course, 10 hours, was reduced by 25% (RPR = 1.33), giving a relative efficiency ratio of 6.30. As administered to employees, the 10-hour course required two days for presentation, the 7.5-hour programmed course one day; as a result, instructional costs were reduced by almost 50%.

If the teachers for whom a PT course is designed are not trained in the subject matter to be taught, the course may be designed so that essentially all of the necessary subject matter information is obtained from an appropriately designed text, more conventional books, or other teaching materials. In that case the primary function of the programmed teacher or tutor may be limited to the management of a pupil's interactions with teaching materials.

Both programmed group teaching (PGT) and programmed tutoring (Pt) have been used successfully to teach reading skills and other academic subjects at the secondary and adult levels, but most applications have been directed toward preschool through third-grade levels, where children may not be sufficiently literate or self-disciplined for PL.

Examples of widely different forms of Pt that satisfied the RPR ≥ 2 criterion include Hofmeister's Telepac programs (Exhibits 89-92), which enabled handicapped children to be taught basic survival skills by their parents at home, and Rosenbaum's Peer Mediated Instruction techniques (PMI) (Exhibits 99-102), which have been used to enable adult immigrants to teach English to each other, to enable third-graders to teach each other to spell, and to enable secondary-level students to teach each other remedial reading and mathematics, all with RPRs ≥ 2.

An outstanding example of PGT is Bereiter and Engelmann's Direct Instruction method (Exhibits 76, 93), first evaluated at the preschool and first-grade levels with disadvantaged children. In comparisons with several other methods, this procedure satisfied the RPR ≥ 2 criterion for gains in Stanford-Binet IQ and California Achievement Test scores in reading and mathematics. In a later national study (15), in which 13 teaching techniques developed by leading educators were compared, the Direct Instruction method produced substantially higher average effects than any other model evaluated. Although it was classified (by content) as a basic area model by Follow Through Project analysts, in rankings of the 13 methods on multiple measures in the basic, cognitive, and affective areas, the Direct Instruction model placed first in all three areas.

Partially Programmed Teaching (PPT)

As the PPT category is defined here, it includes only combinations of programmed and conventional instruction in which the two components have been sufficiently modified and integrated that the combination must be considered as a single method. Combinations in which fully programmed instruction is used as a supplement to conventional instruction, or in which conventional instruction supplements programmed instruction (as, for example, in Exhibit 82 or the Open University plan, Exhibit 58), are not categorized as PPT.

One questionable example of PPT so defined is represented in Exhibit 105. The instructional method represented in this exhibit is described in an ERIC document resume as follows: "The experimental program correlated reading and writing instruction in a highly structured design for the purpose of improving expository writing." It was assumed that "highly structured" meant "programmed." Data presented in the source for this exhibit indicated that the RPR ≥ 2 criterion for this procedure was satisfied for indices of reading as well as writing performance, and for two other measures. Ambiguity in presentations of the experimental teaching procedure scattered through the source report indicated that part of the procedure was unstructured, but did not permit further characterization of the method that was evaluated.

The remaining 15 exhibits categorized as PPT (Exhibits 106-120) appeared in a single source titled *The Concepts of Performance-Oriented Instruction Used in Developing the Experimental Volunteer Army Training Program* (94). This paper, written by Taylor, Michaels, and Brennan (hereafter referred to as TMB) was prepared for the Office of the Chief of Research and Development, U.S. Army, by the Human Resources Organization (HumRRO). The two purposes of the paper were to present results obtained in a major instructional development project aimed at the improvement of 16 technical skill courses in the U.S. Army's basic training program, and to present a pragmatic analysis of the performance-oriented instruction principles that had been applied in the development of these courses. At the time this work was being done, Army basic training courses were being taught by conventional procedures which TMB described as:

> Familiarization and orientation instruction...a lecture-demonstration-practice paradigm...lock-step instruction ...an instructor role of mainly presenting information... testing only at the end...[using] alternate forms of a standard written/performance test using a 70% passing normative criterion.[4]

This description also characterizes the control treatment in the evaluations of the new courses.

Teaching procedures that differentiated the 16 new courses developed by TMB were not described in the report except by course names that identified content, the subject or skill taught in each course. However, the overall treatment that was common to these courses is clearly described. It is a minimally programmed form of interactive teaching that TMB identify as performance-based instruction (PBI).

The programmed portion of the PBI procedure consisted of four steps which precisely specified the conditions (performance criteria) that must be satisfied in making a single instructional decision, i.e., the decision to present or not to present conventional instruction. This conventional instruction is, of course, the unprogrammed component of the PPT procedure. In the form of PPT developed by Taylor's group, the programmed portion of the instructional process is necessarily preceded by an explicit (but not programmed) instructional design procedure that involves determination of course objectives and their conversion to test item or test situation form (see references 4, 54, and 91).

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[4] J. E. Taylor, E. R. Michaels, and M. F. Brennan, *The Concepts of Performance-Oriented Instruction Used in Developing the Experimental Volunteer Army Training Program*, HumRRO Tech. Rep. 72-7 (Alexandria, Va.: Human Resources Research Organization, March 1972).

In the experimental course procedures, both teacher and learner were provided with a list of the instructional objectives for the course and, for each objective, a precise description of a test situation and an equally precise set of specifications for an acceptable performance in that situation, i.e., the response or class of responses to the situation that would satisfy the objective. The teacher was also provided with a set of instructions (that in PT is called an item program) which in this case consists of a sequence of four rules:

1. Present the learner with a test situation from the list.
2. Compare the learner's response (performance) with the specifications for an acceptable response to the test situation.
3. If the learner's performance satisfies the specifications, inform the learner, go to the next situation on the list, and repeat steps 1-4.
4. If the learner's performance does not satisfy the specifications, teach the learner what he needs to do in order to satisfy the specifications, using procedures chosen by the teacher.

At this point in the program, conventional instruction replaces programmed instruction, and suggestions concerning teaching procedures replace rules. Conventional self-instruction, study of technical manuals and other material, supervised and unsupervised practice, and assistance from teachers or tutors and from peers who had completed their own assignments were mentioned as aspects of the instructional procedure. The degree to which decisions concerning these details were left to the discretion of the instructor and learner is not clearly indicated in the report.

For 11 of the 16 courses constructed on this plan, the RPR ≥ 2 criterion was satisfied for an index representing the proportion of students passing a criterion test that represented all requirements for the course. Fifteen of the 16 courses satisfied a similar criterion for the proportion passing one or more subtests.

The principles underlying the new courses were described by TMB as "summaries of conclusions taken from research and practice":

> 1. *Performance-Based Instruction*. The premise of this method of instruction is that the most effective learning occurs when the student becomes actively engaged in the process of learning. To bring the student to active participation, the purpose of instruction has to be thought of as equipping him with skills and capabilities. The subject-matter curriculum is inappropriate in this context, because it stresses what information and facts are to be presented to students to digest and memorize. Performance-based instruction translates the subject matter into the skills and capabilities that the student is to acquire as a result of instruction.
>
> 2. *Absolute Criterion*. When a student has learned to perform a skill, there must be some standard against which his performance is evaluated. For self-evident reasons, partial success in performance of a skill is unacceptable. Either a student knows how to perform a skill or he does not. Under performance-based instruction, the standard is absolute. When a student is unable to perform a skill, he receives additional training until such time as he demonstrates that he is proficient in that skill.
>
> 3. *Functional Context*. If the conditions for learning are arranged so that the student sees the usefulness of that instruction and can apply it in solving a problem and in relating technical information to application in a concrete setting, that instruction takes place in a functional context. For example, learning in a functional context takes place when a student sees the effect of an abstract principle in a specific and actual situation, and when a particular skill is related to its utility in solving a real-life problem. Functional context refers to the application of technical and abstract information in a situation where the student can see its importance and relation to the skill he is learning.
>
> 4. *Individualization*. One of the main variables in learning is the amount of time allowed for a student to learn. Instruction that has an arbitrary time limit ignores the fact that students learn at different rates. Instruction that permits the student to learn at the rate necessary for him to acquire a skill is termed individualized instruction. The methods of individualized instruction should offer the student the opportunity to practice, repeat, and review the skill to the extent necessary for him to learn.
>
> 5. *Feedback*. When the student is actively engaged in learning a skill, he has to handle, and to practice with, the instructional materials. This situation has obvious advantages to the training manager, instructor, and student. All know how the student is learning, because there is ready evidence in the nature of the student's performance. All can easily assess where the student is having problems and where additional practice and instruction are necessary. This immediate knowledge of the results of instruction is called feedback.
>
> 6. *Quality Control*. A training system must have empirical evidence that the students have learned what was intended for them to learn. Through performance-based instruction, a training system has a direct means of verifying the quality of its instruction. Because students have learned skills, what they are able to do as a result of instruction is readily observable. Data on all students' performances can be gathered so that the strengths and weaknesses of the entire training system can be identified.[5]

These principles were written in the context of instructional system design for military training. They are applicable, with some modification, to the design of many instructional units – e.g., courses – in academic curricula. R.G. Smith, in *The Engineering of Educational and Training Systems* (91), has provided a detailed analysis of such applications, written from the point of view of a training systems designer but extended to general education.

In his *Taxonomy of Educational Objectives: Cognitive Domain*, Benjamin Bloom (4) throws light on several key principles that facilitate translation from the language and practices of training to those of academic education when he describes academic test items and examination questions as "illustrations" of educational objectives, and calls most of these illustrations examples of skills rather than knowledge. The translation process may be demonstrated here if one replaces the word 'training' with 'education', interprets 'skill' to include 'intellectual skill', and inserts 'student' for 'soldier' or 'men' in the following extension of the preceding quotation from TMB:

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[5] Ibid.

> To design a training system that would incorporate these six principles requires that priorities be established. The first priority is to identify the specific skills that men learn within a subject area. Once the specific skills are identified, they must be analyzed in terms of the tasks that comprise the skills.
>
> The second priority is to use skills, broken down into a set of component tasks, for the program of instruction and the performance tests given at the completion of training. The performance tests specifies [*sic*] the sequence of steps the men must perform to show that they have acquired the skill. The tests define the conditions under which the soldier demonstrates proficiency, and they designate the standards of performance the men must attain. The program of instruction and the performance tests were essentially identical. To teach a man a skill, the tasks that comprise it must be specified. To evaluate a man's performance of a skill, the sequence of tasks he must perform also must be specified.
>
> The third priority is to provide instructional methods that allow men to learn the skills as completely and as actively as possible. The general model for instruction is to curtail long blocks of verbal presentation, provide a succinct demonstration of the skills by the instructor, and permit men to practice and repeat the skills until they acquire them.[6]

There is an important alternative to the classification of the TMB exhibits as PPT. These exhibits can also be categorized as examples of performance-based instruction (PBI). This discovery is potentially of great importance since it appears to apply equally well to essentially all of the exhibits in the PL and PT categories. If so, some 70% of the teaching procedures which satisfied the RPR ≥ 2 criterion are examples of a single basic teaching procedure, PBI. In what follows, this technique is examined in some detail.

The categorization of Exhibits 106-120 as examples of PPT may be questioned. Taylor et al., identified their basic teaching procedure as performance-based instruction (PBI) and did not explicitly indicate that any part of their procedure was programmed. Our assumption that it was (partially) programmed may be gratuitous, though the four procedural rules that we described as programmed were obviously highly structured and rigorously enforced. If the TMB procedure is not considered to be programmed, what we have called partially programmed teaching (PPT) becomes a strictly supervised and highly structured form of conventional instruction (CI). As such, and classified as a management procedure, it is an example of CtCT; classified as a teaching procedure (PBI), it is an example of PMCT.

The PBI technique is basically simple. It can be described by a sequence of four procedural rules (see PPT above) that can in turn be summarized in a single principle of performance-based instruction (PBI): *Base instructional treatments on the acceptability of learner responses to test situations that represent instructional objectives.*

The reclassification of the TMB exhibits, made late, when publication deadlines were pressing, led to an important insight: Not only TMB's examples of PPT but all forms of programmed instruction (PI) *narrowly defined* (see introductions to the PL and PT sections) may be classified as examples of PBI. When the collection as a whole was reclassified in the light of this insight, 91 exhibits, or 72.8% of the procedures that were found to satisfy the RPR ≥ 2 criterion, were also found to be (or, in a few cases of ACT, to include) examples of the single teaching procedure, PBI.

The 91 examples of PBI included 71 exhibits categorized as fully programmed instruction (PI), either programmed learning (PL) or programmed teaching (PT); the 15 examples of PPT developed by TMB; and five exhibits in the ACT category, i.e., four in which unprogrammed PBI is reported as a component (Exhibits 10, 12, 14, 16) and one in which PI is reported as a component (Exhibit 11). Two examples of PI (Exhibits 34 and 105) were not classified as PBI since the procedures described for them suggested that they did not satisfy the narrow definition of PI.

It is of interest that the applications of PBI in fully programmed PI are examples of the psychotechnology of teaching, and the four examples of unprogrammed PBI are examples of the art of teaching. For one interested in improving the productivity of the art of teaching by applying the psychotechnologist's knowledge of PBI, it would be useful to know the general rules for teaching with PBI that instructional designers have used in the development of PBI-form PL and PT programs. As applied in PI, these rules are reflected in four models: the reinforcement model, the informational feedback model, a combination of these two, and the encouragement model.

1. ***The Positive Reinforcement Model.*** The basic procedure in this model is stated as follows: *Test, using a test item or test situation that represents an instructional objective. If the learner's response to the test is acceptable, follow the response with positive reinforcement; if not, ignore it.* This procedure, unprogrammed, also called "positive behavior modification," is an important component of the experimental treatment in Exhibit 16 (ACT). Together with Exhibits 10, 12, and 14, this exhibit demonstrates the feasibility of using unprogrammed PBI as a procedural modification of CT. Unfortunately, the effects of PBI and other aspects of ACT are confounded in the design of the evaluation procedure in all of these exhibits, so that further research is indicated to evaluate the contribution of PBI to the results obtained. Such research is especially needed in the case of Exhibit 16 because of the nature and apparent generality of one of the outcomes that was reported for that exhibit – a reduction of classroom disruptions by a factor of 4+ at both elementary and middle school levels. Such a spectacular demonstration of discipline without punishment deserves detailed critical examination.

The primary function of the positive reinforcement model is to strengthen or modify responses that occur with nonnegligible frequency. It is not widely used for academic instruction either in CT or PI forms. In the form of praise or reward for good behavior, however, it is highly recommended as a method for child training.

2. ***The Informational Feedback Model.*** The basic procedure in this model can be stated as follows: *Test, ignore ac-*

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[6] Ibid.

ceptable responses to the test situation or questions, and follow unacceptable responses with appropriate informational feedback, e.g., lecture, directed reading or practice, instructions, or an acceptable answer to the question. This PBI procedure, perhaps the most common teaching procedure used in PL designed for literate adults, can also be recognized in unprogrammed forms of the recitation method that appear in CT and CtCT form. Systematic use of PBI greatly increases the efficiency of both CT and PI by eliminating unnecessary teaching. However, it is not well adapted to the teaching of young children (and immature adults) since, for them, the ignoring of success may function as punishment. When discipline is not a problem, the informational feedback model of PBI is better adapted to academic instruction, i.e., instruction in the cognitive domain, than is behavior modification. In general, the latter is better suited to the "molding" of behavior in the affective and conative domains.

3. ***The Combination Model.*** The basic procedure for this model is: *Test, reinforce acceptable responses, and follow unacceptable responses with appropriate informational feedback.* This form of PBI, the basic teaching model for almost all examples of PT, combines the reinforcement of behavior modification with informational feedback in a pattern that is well suited to teaching at the elementary and lower levels. Young children and the educationally and emotionally handicapped need both positive reinforcement to build motivation and informational feedback designed to teach, i.e., create new responses that they might otherwise never make. Society, if not nature, decrees that children should be taught appropriate conative-affective as well as cognitive (academic) responses to test situations. The combination model can do both.

The following model, an extension of the combination model described above, is frequently used in applications of PT to the teaching of young children because of its special effectiveness in building and maintaining attention and motivation for learning. Made concrete by development into an instructional program and properly administered, this model can provide 100% success (and reinforcement) after unacceptable responses without damage to the underlying learning processes of the combination model, and there are benefits for the learner's integrity and self-respect.

3-A. ***The Encouragement Model.*** The basic procedure here is: *Test, reinforce acceptable behavior, and follow unacceptable responses with 1) appropriate informational feedback designed to enable the learner to make an acceptable response, b) re-test, and c) follow acceptable responses to the re-test with reinforcement.*

This procedure provides immediate remedial treatment for undesirable emotional responses that are likely to occur after failure. Such responses may be especially acute, even pathological, in failure-prone and success-deprived learners, e.g., slow learners, or the educationally, mentally, or physically handicapped. The encouragement model provides the learner with an opportunity to respond successfully to a test situation in which he failed, by re-presenting that situation under conditions that almost guarantee success – and the reinforcement that emphasizes it. One form of these conditions occurs immediately after the learner has been taught an acceptable response.

The encouragement model is based on 1) extensive learning research which shows that motivation – i.e., resistance to extinction – is increased by immediate reinforcement and decreased by failure of nonreinforcement, and 2) much relevant information that is available from artistic master teachers if one knows what questions to ask. The most useful questions begin: What will happen if I do this. . .? *This* is a teaching procedure suggested by learning research.

The models listed above are but a few of many, perhaps hundreds, of instructional procedure models that have been developed by instructional systems designers. Few are so basic as the four just listed. Most are variants of PBI, extensions or combinations of a few basic models of PBI, each developed to solve a particular educational problem posed by curricular requirements, pupil or teacher characteristics, limited budgets, and other practical constraints. Not all are models of PBI. Collectively they are available for examination in the form of item programs published by the educational research journals and newsletters (e.g., 26, 47, 78), separates, or in commercially available products of instructional systems designers, e.g., in PI materials or the tutor's guides that contain the programs used in PT. Collections of these programs – or abstracted models of them in the form of annotated anthologies or systematized taxonomies of tested teaching procedures – are not available. If they were made available, and if they were used by those concerned with the improvement of conventional teaching, such collections could provide a positive answer to Gage's question, "Can science contribute to the art of teaching?" (35)

Performance-Based Instructional Design (PBID)

Performance-based instructional design (PBID), like PBI, is an application of a common and important principle of instruction, namely, decide whether to teach, what to teach, and how to teach it, based on information derived from comparisons of pupil performance with instructional objectives. It may be considered a special form of the PBI principle.

The general form of PBID procedures is summarized in the following seven-step algorithm.

1. Specify the terminal instructional objectives for the unit of instruction being designed. Omit objectives that pupils for whom the unit is being designed can satisfy before the unit is taught to them.
2. Convert the set of terminal objectives, or representative samples of them, to the form of test situations (test items or frames). Specify standards of acceptable response to each item. Construct a criterion test or tests from these items.
3. Develop a teaching procedure to achieve the terminal objectives specified in step 1, or the criteria developed in step 2.
4. Teach a representative sample of the population of pupils for which the instructional unit is intended, using the

teaching procedure developed in step 3 (or as modified in step 6).

5. Administer and score one or more of the criterion tests developed in step 2 to the pupils taught in step 4. If pupil performance is satisfactory, stop; otherwise:

6. Utilize information derived from comparisons of pupil performance with instructional objectives to modify (attempt to improve) the teaching procedure used in step 4.

7. Repeat steps 4-6 indefinitely, each time with a new sample of the population of pupils for whom the unit of instruction is being developed. Repeat until pupil performance is satisfactory as indicated by criterion test performance.

Five exhibits were categorized as examples of PBID. In all of these exhibits the source papers gave greater emphasis to the process by which the experimental teaching procedure was designed than to the teaching procedure itself. Three of the exhibits (121, 122, 123) are examples of military training course design which appear to represent a special application of the PBID algorithm in which the design process is repeated only once. It stops with step 6. In this case the information used in constructing the original design may be derived from general knowledge, e.g., knowledge of learning principles, of human behavior in general, or of the art of teaching. In the absence of specific knowledge based on direct comparisons of pupil performance with the instructional objectives specified in step 1, the design procedure in this case may be better described as objectives-based instructional design (OBID) than PBID.

The two remaining exhibits are of special interest as examples in which PBID is applied to the improvement of conventionally taught courses, one in a military training setting, the other in a traditional educational (school) setting. Note that in this case the course is already designed. Step 3 is therefore omitted on the first cycle through the procedure.

Sherrill (Exhibit 125) applied PBID during 18 successive presentations/revisions of a conventionally taught nine-week training course in military court reporting. Instructors were qualified by experience and training as military court reporters but had no prior professional qualifications as teachers. Sherrill described his procedure as follows:

> The continual formal evaluation took the form of, class after class, course supervisor and the instructors reviewing the results of a (criterion) test, identifying those items most frequently missed, and adjusting their next presentation in hopes of reducing the miss rates of the scorable test items.[7]

Improvement in student performance (and, therefore, teacher performance) in successive classes was progressive but irregular. Using the performance of the first class as a baseline, the RPR ≥ 2 criterion was satisfied by the fourth class, and approximately two years later by the 17th and 18th classes of students, with RPRs of 2.2, 2.56, and 6.25 respectively.

Melaragno (Exhibit 124) reported similar results for an application of PBID to academic instruction in a public school setting. In Melaragno's study reading performance of first-grade, second-grade, and third-grade pupils in one school was scored on standardized tests annually for a five-year period during which conventional teaching of reading was supplemented by conventional tutoring (CtCT). During this period PBID techniques were applied continuously to improve instruction. Melaragno summarized his procedures as follows (Note that the technique we have defined as PBID, Melaragno calls OBID.):

> *Objectives-Based Instruction*. The reading instruction used is objectives-based: It contains clearly specified instructional objectives along with materials and procedures designed to enable students to achieve the objectives. An integral part of such objectives-based instruction is the incorporation of frequent testing procedures that indicate to a teacher which objectives a student has mastered and which skills require further instruction. Objectives-based reading instruction is used in all classrooms at all grade levels.
>
> *Tutoring Programs*. A school-wide tutoring program is conducted in which older elementary school students tutor primary grade students. In addition an interschool tutoring program is carried out in which junior high school students tutor underachieving elementary school students. These programs are part of the ongoing reading instruction; students acting as tutors are trained carefully in procedures to implement the objectives-based instruction used throughout the school. Tutoring is one important way in which instruction is individualized.
>
> *Program Monitoring System*. All aspects of the school – instructional programs and support programs – are monitored by means of a program evaluation conducted every 10 weeks. This monitoring system provides information concerning progress toward objectives and ratings of effectiveness of program elements. It yields information on strengths and deficiencies so that staff involvement, planning, and decision making can be carried out accurately and efficiently. Detailed data are collected on each student's progress in reading; modifications to the total program and allocation of resources are made whenever the monitoring system indicates the need.[8]

Unfortunately, the power of Melaragno's demonstration was weakened by a decision of the host school to change the tests used for evaluation during the course of the experiment – from the Stanford Reading Achievement Test to the Cooperative Primary Reading Test. Whatever their virtues, these tests have different norms based on different samples. As a consequence, it is impossible to make the comparisons necessary to evaluate some of the changes in pupil performance that occurred between the first and fifth year of the five-year evaluation study. However, examination of data obtained in comparisons in which the same test was used for both of the years compared indicates that year-to-year improvements in pupil performance were generally large, relatively continuous, and cumulative. The RPR ≥ 2 criterion was satisfied in 15 such comparisons.

One other exhibit in the collection, Exhibit 78, may be an example of PBID or OBID. If the data can be supported by a more adequate description of evaluation procedures than the source provides, this may be one of the most significant exhibits in the collection. Although the data in Exhibit 78 are plausible in the light of Melaragno's data, and that summarized in other exhibits in the collection, they were available only in the form of an advertising brochure which did not contain the procedure section that is taken for granted in professional evaluation reports. Attempts by the author and the Phi Delta Kappa staff to remedy this inadequacy have failed. The developer of the teaching technique is deceased. An attempt to communicate professionally with the present proprietors was answered only by delivery of another copy of the brochure.

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[7] J. L. Sherrill, *Competency-Based Testing in a Communicative Arts Task* (Fort Benjamin Harrison, Ind.: Directorate of Training Development, U.S. Army Administration Center, June 1978).

[8] R. J. Melaragno, *Influence of the Tutorial Community Project on Reading Achievement at Pacoima Elementary School* (Pacoima, Calif.: Tutorial Community Project, 1973).

It should be mentioned that the incidence of PBID in the collection is not limited to the five exhibits discussed above. The seven steps in the PBID algorithm systematize a variety of explicit procedures that instructional systems designers have developed and use routinely in the design of instruction, especially the forms categorized as PL, PT, PPI, and PBI. More generally, the algorithm may be considered as an explicit behavioral model for the covert mental or cognitive processes that master teachers have long used to develop and hone their "inborn" teaching skills.

Warning: The application of PBID may be dangerous, either to your pessimism or to your peace of mind. Applied to the design of programmed instruction, it has produced some 70% of the exhibits in this collection. Applied more generally and less ideologically, it has produced at least two examples of conventional instruction which also satisfied the RPR $\geq$ 2 criterion (Exhibits 124 and 125). Applied consistently and rigorously as a routine administrative procedure in schools with concerns for practicality, cost, and excellence, PBID may enable those schools to achieve, or at least approach, excellence.

Achieving this result may require a radical redesign of the role of teachers; radical changes in the organization, management, even the architecture of schools and classrooms; and corresponding changes in the curricula for training teachers and school administrators. If we seriously consider cost reduction as well as excellence to be objectives of our educational system, and if we apply PBID for the more general systems approach from which PBID is derived, it is not unreasonable to believe that we can achieve both objectives simultaneously.

Instructional Costs

Costs per se are mentioned in only two studies in the collection, both of which evaluated full scale working educational systems rather than single teaching methods. In both studies large reductions in costs were reported with no evidence of reduction in the quality of instruction and with many indications of other benefits. In both cases programmed instruction was the primary instructional technique, PL in one case and a combination of PT and PL in the other.

The Open University system (30 and Exhibit 58), utilized PL in each student's home as an alternative for conventional on-campus lecture and laboratory procedures. The PL is supplemented by mailed tests and examinations and to a limited extent by lectures on radio, TV lectures and demonstrations, tutoring, self-instructional laboratory kits, and, at the end of each year, by one week of intensive conventional lecture, laboratory, or practicum on a traditional university campus. Teaching effectiveness was reported to be equivalent to that of conventional university instruction. Costs and therefore cost-effectiveness were increased by a factor of 3, and costs to students were reduced by a factor of 5.

The IMPACT system for elementary instruction (57, 60, 83, and Exhibit 95) was developed experimentally in the Philippines. With the exception of physical education, art, music, and scouting (a national requirement), which were taught conventionally by special visiting teachers, the entire elementary curriculum was taught with the IMPACT system. In this system, fourth, fifth, and sixth grade pupils taught themselves individually and in spontaneously organized small groups using a "module system," a special form of PL that, like the form of PL used in the Open University system, utilized relatively large and complex frames or modules. The older pupils also spent approximately one hour per day teaching groups of eight to 10 first-, second-, or third-graders, using PT techniques. In rural schools of some 200 pupils each, two instructional supervisors, professional teachers with special training in the IMPACT system, were responsible for management and supervision. An instructional supervisor did no personal teaching except to train the pupils to participate as learners and teachers in the system and occasionally to teach in the role of trouble-shooter. A set of five such schools were administered by a "Rural Coordinator/Educational Analyst," a roving principal responsible for administration and academic supervision.

An evaluation of the teaching effectiveness of the IMPACT system, using external examiners who administered national tests that had been developed a few years earlier to evaluate conventional elementary school instruction, showed that for all academic subjects combined, scores for pupils from IMPACT schools were 9% higher than those from comparable conventional schools (RPR = 1.09), and costs were 50% less (RPR = 2.0). Relative to comparable control schools, cost-effectiveness was more than doubled (RPR = 2.18).

It is of interest to compare cost figures obtained for the IMPACT system with those for a parallel project, PAMONG, in Indonesia. The methods developed by this project to teach its own national curriculum were essentially the same as those developed by IMPACT. Teaching effectiveness was presumably equivalent or better. An early formative evaluation study reported test scores for PAMONG schools to be 25% higher than those for comparable schools (RPR = 1.25). However, the PAMONG project did not reorganize its experimental schools as Project IMPACT did in order to take advantage of the potential cost-reduction provided by the instructional system. At PAMONG the conventional intact classroom structure was retained and the teacher of each class, after appropriate training, served as instructional supervisor for that class. Costs for teaching materials increased by 20%. As a result, overall costs were slightly larger than costs for conventional instruction. Using cost data from the Philippine cost-effectiveness study to estimate PAMONG costs, RPR for costs was 1.01.

Cost data were not given for other exhibits in the collection. However, instructional costs and, given RPRs for teaching effectiveness, relative cost-effectiveness, can be estimated with some confidence from technical data that are commonly reported in evaluation studies – e.g., number and qualifications of teaching personnel, pupil-teaching ratios, teaching materials, and special equipment utilized in the experimental treatment.

Table 2 summarizes a number of estimates of instructional costs that are likely to be encountered in applications of techniques represented in Table 1. Estimates for a few other techniques of interest have been added. Estimates of program unit costs, program-hour costs, and pupil-hour costs for a number of instructional and instructional management procedures are presented, together with RPRs obtained by comparing pupil-hour costs for each technique with pupil-hour costs for the baseline procedure, CT_{18}.

Most of the cost estimates represent highly educated, and therefore defendable, guesses, modified in some cases to keep the estimates conservative. An exception is the estimate of costs for CBBI, the unprogrammed study of conventional books in school, at home, or perhaps in a hospital, a prison cell, or a cabin. What, for example, is a reasonable estimate, at today's prices, of the cost of an education obtained from Carlyle's "true university," or the costs of the law degree obtained at that university by Abraham Lincoln? What is a representative cost for the books that a first-grader or a research professor might study in 180 hours?

Relatively little of the information in Table 2 was derived from the collection itself. For the most part it represents a general knowledge of costs and school practices in U.S. educational and training institutions, supplemented by data recently published by USOE and by some general knowledge of costs involved in applications of various forms of PI to special problems of education in the U.S. and developing countries. The rationale and calculations reflected in these estimates are made explicit so that the reader can make his own estimates and computations if he disagrees with those given in the tables. Rationale and comments on the estimates follow.

The estimates are presented in two sections – Section A: Conventional Teaching and Management Procedures, and Section B: Independent Study Alternatives and/or Supplements to Conventional Teaching. It may be noted that all of the instructional procedures described as supplements to CT in Section B can function independently of conventional classroom instruction.

The cost calculations in Table 2 begin with an estimate of basic program unit cost, the first-year cost of a program unit usually designed to provide instruction for a one year "course" in a given subject area. The numerical subscript to the category designation indicates the typical class size or pupil-teacher ratio for the program unit. The letter subscript (U or P) indicates whether teaching personnel are unpaid or paid. For variants of conventional instruction the unit cost is taken to be the annual salary of a professional teacher plus contingent support costs, roughly the equivalent of the nine-month instructional costs for a one-room, one-teacher school. Support costs, assumed for the sake of simplicity to be independent of pupil-teacher ratio, are estimated to be 25% of the teacher's salary, following a common rule of thumb that teacher salaries are 80% of the cost of instruction. For supplements listed in Section B, whether they are conventional or programmed, basic program unit cost is taken to be the cost of necessary instructional personnel salaries, teaching materials, special equipment, and maintenance of equipment.

Program cost per year, or annual program cost, is calculated by dividing basic unit cost by the estimated useful life of the program, assuming that it is used full time, i.e., 6 hours per day, 180 days per year. Program cost per hour is then calculated by dividing annual program cost by the number of hours in a U.S. school year, which is taken to be 1,080, 30 hours per week for 36 weeks. Program cost per pupil-hour is calculated by dividing program cost per hour by the number of pupils that are typically taught at one time with one program unit.

Section A: Conventional Instruction and Management Procedures

Lines 1-4 present cost estimates for conventional professional teaching with several pupil-teacher ratios. The basic unit costs, $25,000 in all cases, is derived from recent USOE reports of the average salary for U.S. teachers circa 1982-83 (plus 25%). The cost estimates for this group of CT procedures reflect the simple assumption that the cost of teaching varies inversely with class size.

Line 2, CT_{18}, represents an estimate of instructional costs for the average U.S. class, which, according to USOE data, has an enrollment of approximately 18 pupils. Estimated cost per pupil-hour for CT_{18} ($1.29) is used as a baseline in cost comparisons with other class sizes for CT and other techniques of teaching.

Line 4, CT_1, provides an estimate of the cost of full-time professional tutoring. This method, long used to educate the sons of aristocrats and now almost extinct, was described by Bertrand Russell as "arithmetically impossible" (82). It is obviously very costly. This method of instruction was largely replaced by the less costly classroom method when the democratization and industrialization of society created a need for mass education and at the same time for a more effective and economical method of instruction. (According to the *A Nation at Risk* report, this need has returned as a consequence of further social changes.) In terms of today's prices the shift from professional tutoring to CT_{18} reduced costs by a factor of 18, more than one order of magnitude.

It is generally assumed that CT_1 is more effective as a teaching technique than CT_{18}, but this assumption can be doubted. Did the sons of aristocrats who were taught, say, in the 18th or 19th century by CT_1 procedures learn *more* than the sons of modern aristocrats taught in the 20th century by CT_{18}? Note that in answering this question, preferences for subject matter, e.g., the classics or a modern curriculum, are irrelevant. The question is concerned with quantity, which is more or less independent of what is taught, i.e., independent of curriculum content or objectives.

Lines 5-7 present cost estimates for variants of CT that can increase teaching effectiveness while leaving costs essentially unchanged. In the collection, these variants are represented by 16 exhibits. Eight of these (the CMCT exhibits and PMCT Exhibit 32) represent modifications of the art or practices of teaching. The remaining eight represent modifications of the management practices, including the seven CtCT exhibits, which supplement CT with unprogrammed tutoring by unpaid students (see Line 11), and PMCT Exhibit 31.

If the PPI techniques reported by Taylor, Michael, and Brennan (Exhibits 106-120, first classified as partially programmed instruction) are considered to be examples of unprogrammed performance-based instruction, they may be re-classified as procedural modifications of conventional teaching procedures (PMCT). As examples of PMCT they represent modifications of the art of teaching and may be added to the list of variants of CT.

The source material for these exhibits (94) indicates that Taylor et al. used students as tutors while they were in training. Thus Taylor's technique might also be classified as CtCT.

Line 7, CtCT, represents in-class unprogrammed tutoring by student tutors as a supplement to CT. Tutoring within the classroom is usually but not necessarily done by student tutors; elsewhere, e.g., at home, it is usually done by unpaid volunteers. Insofar as the tutoring materials, e.g., textbooks and writing materials, are those already in use and available in the classroom, or are paid for by students, the introduction of CtCT has a negligible effect on instructional costs. Monitoring, e.g., training and supervision of tutors by the classroom teacher, can be treated as a real cost, but as used in CtCT (in the classroom) it does not add to the cost of CT and therefore is not represented in school budgets.

CtCT using paid tutors (no examples appear in the collection) may be considered as a special case of ACT in which tutoring is the only form of augmentation. When tutors are paid, the hourly pay rate of the tutor must be added to pupil-hour costs for CT.

Line 8, ACT_9, represents supplemental augmentation of conventional teaching. Costs were difficult to estimate for the ACT category because of the heterogeneity of the techniques it represents. However, it was noted that most of the sources for ACT exhibits reported small class size as one aspect of the procedure. It has been assumed, therefore, with appropriate reservations, that ACT may be redefined as ACT_9 plus other forms of augmentation. The cost of ACT_9 is then estimated to be double the cost of CT_{18} plus the additional costs. In that case, the unit cost of ACT_9 is estimated to be $25,000+, and cost per pupil-hour to be $2.58+.

Presumably the total cost of ACT_9 will be less than the average for CT_1, but there can be exceptions. Consider pilot training as a form of ACT and the cost of ACT when used to solve some of the special instructional problems posed by mental and physical handicaps.

Line 9, MLC_{81}, identifies the Monitored Independent Learning Center experience. This procedure/facility is not represented in the collection. MLC is an extention of the concept of independent study for which study halls were invented. It is utilized not only for unprogrammed self-instruction with the aid of books and pencil and paper, but also for PI, mutual instruction by groups of students working in groups of two or more with or without the aid of programmed textbooks, guides for programmed teaching and tutoring, film viewers, computers, etc. The study hall monitor, usually but not always a professional teacher, remains as an instructional supervisor in MLC, not primarily to teach, of course, but to provide the minimal forms of support, supervision, and other sorts of academic troubleshooting that are desirable for pupils who must learn to learn in the absence of teachers.

Program unit cost for the monitoring function performed by a professional teacher or non-professional person in a study hall or learning center is calculated as the salary of the monitor plus the support costs for a professional monitor. The cost of monitoring by the classroom teacher within the classroom, or by an unpaid volunteer anywhere, is assumed to be nil.

Experience with conventional study halls, and more recently with the IMPACT plan and computerized programmed instruction of individuals (CAI) and groups (CDI), indicates that a pupil-monitor ratio of 81 for MLC is feasible at the elementary level, and that this pupil-monitor ratio might be doubled at higher levels. Costs for monitoring are estimated by the same formula as those for classroom teaching. Instructional costs for teaching materials, equipment, etc., that are required for the instructional techniques that are monitored are not charged to MLC.

Section B: Independent Study Alternatives and/or Supplements to CT

Cost estimates for instructional techniques reported in this section include only costs that are incurred when the listed techniques are used within a classroom or for home study. Instructional personnel costs for tutors are included in the estimate only when they are specified as an integral part of the instructional procedure. Monitoring costs are not included.

In estimating costs for both the programmed and the unprogrammed instruction that is represented in this section, the basic unit is taken to be a one-year "course" that provides 180 hours of instruction. It is also assumed that the teaching material and equipment for that course will be used efficiently, i.e., six times daily, 1,080 hours per year. It is possible that such efficient usage will not be achieved in schools, so that this assumption, taken alone, results in under-

Table 2

Estimates of Instructional Costs for Variants of CT, Independent Study Alternatives or Supplements to CT, and Instructional Management Procedures

Section A: Conventional Instruction and Management Procedures

Line		Category	Basic Program Unit Cost	Useful Life, Years	Program Cost Per Year	Program Cost Per Hour	Pupil-Teacher Ratio	Program Cost Per Pupil-Hour	RPR VS CT$_{18}$ (inverse)
1	CT$_{27}$	Conventional Instruction$_{27}$ (large classes)	$25,000	1	$25,000	$23.15	27	$ .86	1.50
2	CT$_{18}$	Conventional Instruction$_{18}$ (baseline class size)	25,000	1	25,000	23.15	18	1.29	1.00
3	CT$_{9}$	Conventional Instruction$_{9}$ (small classes)	25,000	1	25,000	23.15	9	2.58	.50
4	CT$_{1}$	Conventional Instruction$_{1}$ (professional tutoring)	25,000	1	25,000	23.15	1	23.15	.06
5	CMCT$_{18}$	Content-Modified CT$_{18}$	25,000	1	25,000	23.15	18	1.29	1.00
6	PMCT$_{18}$	Procedure-Modified CT$_{18}$	25,000	1	25,000	23.15	18	1.29	1.00
7	CtCT$_{18}$	Unprogrammed Tutoring Within CT$_{18}$ (unpaid tutors)	25,000	1	25,000	23.15	18	1.29	1.00
8	ACT$_{9}$	Augmented CT$_{9}$	25,000+	1	25,000+	23.15+	9	2.58+	<.50
9	MLC$_{81}$	Monitored Learning Center$_{81}$	25,000	1	25,000	23.15	81	.29	4.45

Table 2 (continued)

Section B: Independent Study Supplements to Conventional Instruction

Line		Category	Basic Program Unit Cost	Useful Life, Years	Program Cost Per Year	Program Cost Per Hour	Pupil-Teacher Ratio	Program Cost Per Pupil-Hour	RPR VS CT$_{18}$ (inverse)
10	CBBl$_1$	Conventional Book-Based Self-Instruction	$ 180	3	$ 60	$ .06	1	$ .06	21.50
11	CT$_{1U}$	Conventional Tutoring, Unpaid Tutors	0	1	0	.00	1	.00	–
12	Ct$_{1P}$	Conventional Tutoring, Paid Tutors ($5/hr)	5,400	1	5,400	5.00	1	5.00	.26
13	PL$_1$	Programmed Self-Instruction*	180	3	60	.06	1	.06	21.50
14	Pt$_{1U}$	Programmed Tutoring, Unpaid Tutors	180	3	60	.06	1	.06	21.50
15	Pt$_{1P}$	Programmed Tutoring, Paid Tutors ($5/hr)	5,580	1,3	5,460	5.06	1	5.06	.25
16	PGT$_{9U}$	Programmed Group Teaching,** Unpaid Teachers	180	3	60	.06	9	<.01	129.00+
17	CAI$_1$	Computerized PI$_1$	3,680	5	736	.68	1	.68	1.89
18	CDI$_9$	Computerized PGT$_9$	3,850	5	770	.71	9	.08	16.12
19	PBID	Performance-Based Instructional Design	0					0	–

*in the Open University and IMPACT plans
**in the IMPACT plan

estimation of costs. However, it is believed that other factors represented in the estimates – e.g., the use of present list prices of materials for which current demand is small as the basis for estimating costs for possibly large scale use in the future, and the effect of less efficient scheduling upon the usable life of teaching materials – will more than compensate.

Line 10, CBBI$_1$, represents conventional book-based self-instruction. The unit cost, $180, is estimated as the cost for 6 large textbooks totalling 3,000 to 4,000 pages (or perhaps 18 academic paperbacks). This estimate is three times the estimate for textbooks ordinarily assigned in secondary or college courses representing 1/6 of a full course load for one school year. On the assumption that the price of conventional textbooks is not greatly different from that of programmed textbooks, and that they represent an equal amount of study, this estimate is the same as that for the teaching materials required for PL. As suggested above, the unit cost estimate for CBBI may be questioned.

Line 11, Ct$_{1U}$, represents conventional (unprogrammed) tutoring by unpaid student or volunteer tutors. Insofar as this technique is practiced by unpaid tutors or volunteers in connection with school programs, in school or out, and tutoring materials are supplied from the classroom stock, costs to schools are presumably zero or are negligible. See also Line 7.

Line 12, Ct$_{1P}$, represents conventional tutoring by paid nonprofessional tutors (not represented in the collection). Assuming no cost for teaching materials, unit cost for this technique is estimated to be $5,400 – i.e., the payment to a nonprofessional paid $5.00 per hour for a 30-hour week for 36 weeks.

Line 13, PL$_1$, represents programmed self-instruction utilizing programmed textbooks. The estimated unit cost, $180, is the same as that for CBBI. This estimate assumes that six programmed textbooks, costing the same as conventional textbooks, are sufficient to provide 180 hours of instruction in one subject, the equivalent of classroom and study time combined, for two secondary school credits or two 2-credit-hour college courses. Each of these represents approximately 1/6 of a "full course load."

Line 14, Pt$_{1U}$, represents programmed tutoring with unpaid or volunteer tutors. On the assumption that there are no teaching personnel costs and that the cost of programmed teaching material required for Pt$_1$ is the same as that for PL, the program unit cost for Pt$_{1U}$ is estimated to be $180, the same as that for CBBI$_1$ and PL$_1$.

Line 15, Pt$_{1P}$, represents programmed tutoring with paid (nonprofessional) tutors. The estimate assumes teaching materials costs to be the same as those for PT$_{1U}$ and teaching personnel costs to be $5.00 per hour for 1,080 hours.

Line 16, PGT$_{9U}$, represents programmed group teaching, unpaid teachers. This technique was first developed and evaluated as PGT$_{9P}$ in Malaysian rural schools in 1973[9], using paid adult sixth-grade graduates as teachers, and, as PGT$_{1U}$, was later incorporated and indirectly evaluated as a part of the IMPACT project plan. It utilizes essentially the same materials as those required for Pt$_1$, and the same teaching method (PBI), but with modifications in operational programs and manuals. Unit costs for PGT$_{9U}$ are estimated to be the same as for Pt$_{1U}$. Pupil-hour costs are lower, of course, because of the difference in pupil-teacher ratio.

Line 17, CAI$_1$, represents computer assisted instruction, a computerized form of programmed self-instruction that typically incorporates features of PL$_1$ and Pt$_1$ in its software. This technique is represented in the collection by one outstanding example of educational software (Exhibit 33). Beyond this example and a mass of subjective impression, there is little quantitative knowledge of the teaching effectiveness of applications of computer technology in education. It seems likely, however, that when the importance of objective evaluation of computerized instruction is recognized, CAI$_1$ will be found to be no less effective, possibly more so, than other forms of programmed instruction. Computers are more effective than most mechanical teaching machines for implementing programmed performance-based instruction techniques, and a number of such techniques presented by the simpler machines are represented in the collection.

Given the assumptions of our model for cost estimation, unit costs for CAI (and CDI, see below) can be calculated as follows:

Basic unit costs:

Unit costs	*CAI*	*CDI*
1 computer, assumed to have a 5-year useful life	$1500	$1500
Maintenance contract, 5 years	1500	1500
Software for 180 hours of instruction, 5 year life	600	600
Special furniture: table, chairs, 5 year life	80	250
Total costs for basic program unit:	$3680	$3850

Line 18, CDI$_9$, represents computer directed instruction, a computerized form of PGT$_9$ that presents teaching materials on screen and directs the teaching activities of a group leader and the learning activities of the leader and other members of a group of pupils.[10] Applications of this technique have been validated subjectively for practical aspects such as student motivation, involvement, leadership training, and discipline, but its teaching effectiveness has not yet been evaluated directly in terms of quantitative measures. Evaluated indirectly, as an automated form of programmed PBI and PGT, both of which have been evaluated and have satisfied the RPR ≥ 2 criterion for teaching effectiveness, it has promise. Program unit costs for CDI$_9$, which can be estimated with some confidence, are similar to those for CAI_1 (see above). Costs per pupil-hour of instruction for CDI_9 are markedly lower than those for CAI_1 because of the difference in pupil-teacher ratio.

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[9] Ellson, D.G.; Chiam Tah Wen; Le Thi Kim Hai; Ishak b. Khamis; Khamis b. Noye; and Moua Lia. *Programmed Teaching: Effective Teaching by "Unqualified Teachers."* Final Report, INNOTECH/PT(E) – FR/73, SEAMEO Regional Center for Educational Innovation and Technology, Singapore, 1973.

[10] Ellson, D.G.; R.A. Martin; and J.A.V. Fields. Unpublished manuscript.

Line 19, PBID, identifies performance-based instructional design. The identifying characteristic of teaching techniques assigned to this category is not a property of the techniques; it is the process by which the techniques are developed and evaluated, i.e., performance-based instructional design. The PBID process, first used in the development and evaluation of programmed instruction techniques (14,91), can be very costly. In more recent applications of PBID to the improvement of the effectiveness of conventional classroom instruction (Exhibits 124, 125), it is presumably much less costly. In making the zero estimate for instructional costs for PBID in Table 2, it is assumed that PBID costs are development costs. It must be recognized, however, that development costs can be transferred by various means to the instructional budget. They are customarily hidden, for example, in the price of commercially developed programmed teaching materials, or, when PBID is applied in schools (see Exhibit 124), in the salaries of the teachers and others whose time is required to administer the PBID process.

Table 2 presents estimates of instructional costs for the categories and certain sub-categories of teaching procedures identified in Table 1, together with estimates for a few related techniques that are of interest but were not represented in the collection. These estimates provide useful parameters, however approximate, for predicting instructional costs to be expected in practical applications of the techniques represented in the table.

In making such predictions, cost per pupil-hour of instruction is likely to be the most useful index. In terms of this index the range of instructional costs for the techniques represented in Table 2 is more than 2,000 to 1. A meaningful baseline figure for comparative puproses is \$1.29, the estimated cost per pupil-hour of instruction in a class of 18 pupils. According to data recently published by USOE, this is the average enrollment in U.S. classrooms.

High pupil-hour costs are associated with tutoring by professional and nonprofessional teaching personnel who are paid the going rate for persons with their qualifications (CT_1, Ct_1P, and Pt_1P), and combinations of small class size with special teaching materials, equipment, and other facilities (ACT). Estimates for these four techniques are more than double the estimate for baseline cost. It is of interest that other tutoring techniques are among the least costly in the list.

For techniques in the CMCT, PMCT, and, when tutors are unpaid, the CtCT categories, costs are estimated to be the same as those for baseline CT. The modifications of conventional teaching in these categories do not necessarily imply either increases or decreases in the cost of instruction.

When the high cost techniques, Ct_1P and Pt_1P (see above), are excluded, cost estimates for the remaining teaching techniques listed in Section B of the table are less than baseline CT costs. Applications of these low-cost techniques can increase or decrease total instructional costs, depending on the management plan in which they are embedded. Six of these low cost techniques are of special interest because of their exceptionally low cost. For $CBBI_1$, PL_1, Ct_1U, Pt_1U, PGT_9U, and CDI_9, estimates of pupil-hour costs are less than 1/10th, in two cases less than 1/100th the corresponding estimate for baseline CT.

It should be mentioned that two of these categories, $CBBI_1$ and CDI_9, respectively the first and the most recent technologies of independent learning to be developed, are not represented in the collection. Cost estimates presented in Table 2 suggest that both easily satisfy the RPR $\geq$ 2 criterion when their costs are compared with those for CT. There is also reason to believe that these categories represent highly effective instructional techniques and that quantitative evaluations will show that they can also satisfy the RPR $\geq$ 2 criterion for effectiveness.

The common feature of these techniques, which in large part accounts for their low cost, is that all are examples of independent learning. They are forms of self-instruction when the common meaning of this term is extended to include group self-instruction, e.g., peer-mediated tutoring, cross-age tutoring, similar procedures in which members of a group of students teach each other or are taught by a bona fide member of the group, and automated forms of all of these. Note that this definition would exclude most paid instructors.

The primary cost of independent learning represents expenditures for the teaching materials and equipment that are used to support individual or group self-instruction. These costs may represent conventional books, programmed texts, tutors or teachers guides, visual aids, broadcast media, teaching machines, computers, etc., but not, ordinarily, paid teaching personnel. In some school applications, independent learning techniques may be supervised and otherwise supplemented by paid monitors, in which case the personnel costs of the supplementation must be added to the materials and equipment costs. When estimates for monitored learning centers are combined with those for the six low cost independent learning techniques, the average pupil-hour cost is \$.35, approximately 1/4 the baseline cost for CT.

In traditional applications of independent learning techniques, e.g., the application of Ct_1U in CtCT, or of CBBI in monitored study halls or learning centers, special costs for teaching materials or equipment, if any, and for monitoring are added to the cost of CT. As a result, total instructional costs are increased. There is an apparent economic paradox here. Instructional costs are increased by the introduction of highly productive techniques for which costs are significantly less than for the original CT. A solution to the paradox is suggested by a comparison of the traditional procedures for managing the use of independent learning with the instructional management procedures represented in the Open University (30) and the IMPACT project (60,83) systems. In the former, independent learning is treated as a more or less optional supplement to CT, the latter remaining essentially as it was before the supplement was introduced. As a result, instructional costs are increased. In the Open University and IMPACT systems, on the other hand, independent learning is considered to be an educationally significant alternative to CT, as this book shows it to be, and it is treated as a replacement for CT. In these systems the pupil hours devoted to conventional teaching (CT) are reduced in direct proportion to the pupil hours devoted to independent learning. Because of the difference between pupil-hour costs for CT and independent learning, the result is to decrease instructional and overall costs.

The management plans represented in the Open University and the IMPACT project systems are not recommended for general adoption. The particular educational problems that these plans were designed to solve – and did solve remarkably well in spite of the fact that both solutions were first attempts and utilized relatively untried technologies of independent learning – are not universal. One problem was peculiar to university education in Great Britain, the other to elementary education in the Philippines (though similar problems are common in other developing countries). The more general problem identified in the report, *A Nation at Risk* – explicitly the problem of excellence, implicitly the problems of teaching productivity and cost – is likely to be solved by less radical and, therefore, more generally acceptable systems. These systems will presumably be based on the replacement principle in order to reduce costs, but they will not completely or almost completely replace conventional instruction with forms of independent learning, as the Open University and IMPACT systems do. Solutions more appropriate to U.S. problems – and more acceptable to the U.S. public and educators – will almost certainly incorporate a more equal balance between teacher-centered and pupil-centered instruction. They will presumably be designed to provide time for teachers, perhaps more time than they have now, to do what teachers do best, and pupils with more time in the classroom, learning center, or at home to do what they can do best, or just as well but more economically, in the absence of teachers.

Depending on the American problem as it is finally understood, these solutions may not reduce cost at all. They may simply use the savings that can result from the applications of the replacement principle to increase teachers' and instructional supervisors' salaries, reduce effective class size for the CT component of the total plan, or increase teachers' supplies and expense budgets. We can hope that these solutions would be developed in the context of performance-based instructional design. If so, we can not know now the final nature of the instructional systems that will constitute these solutions. A preliminary analysis of such systems is an appropriate topic for another monograph, and one of the next steps to be taken on the way to excellence in education – with economy.

An Incidental Finding

Several times in this monograph I have said or implied that existing research directly concerned with the effect of teaching methods on the effectiveness and cost of teaching is unknown to, or is being ignored by, the educational establishment. Since this opinion, if true, could have a bearing on possible recommendations for action, it is desirable to present some of the evidence for it. Several examples may be mentioned.

1. In the process of assembling the RPR ≥ 2 collection, a number of educators were asked, individually and in groups assembled, to discuss the improvement of teaching productivity. They were asked to cite examples of educational research that presented any evidence in the form of hard data indicating that one method of teaching was at least twice as effective or half as costly as another. Only one of the educators questioned gave a positive answer. He suggested a look at Downing's research on Initial Teaching Alphabet. As a result, one item was added to the collection.

2. In 1975, when the collection included some 25 studies and 41 teaching techniques that satisfied the RPR ≥ 2 criterion for one or more indices, the National Institute of Education conducted a National Conference on Studies in Teaching (65), which consisted of 10 national seminars and resulted in 10 substantial papers reporting proceedings. Not one of the papers in the RPR ≥ 2 collection at that time was included in the references or mentioned in the texts of any of the reports of proceedings, and only one of the authors of those papers was listed as a participant in the conferences.

3. *A Nation at Risk*, whose authors and their consultants presumably have great concern for finding solutions to educational problems, makes no reference to the existence or the promise of research on the effectiveness of teaching, and no author of any paper in the RPR ≥ 2 collection was included among the more than 300 persons listed as sources of information for the report.

Summary

This monograph examines a collection of some 75 empirical evaluation studies, each of which compares two or more instructional practices, techniques, or systems for teaching a particular subject or curriculum in terms of one or more quantitative indices of instructional productivity, e.g., teaching effectiveness (pupil performance), cost factors, or both, and reports large between-group differences. Collectively, the comparisons made in these studies identify 125 instructional treatments for which one or more indices of productivity was double or more than double that obtained for a comparison treatment or treatments (the RPR ≥ 2 criterion).

For technical reasons related to the fact that the purpose of this monograph is primarily technological rather than scientific, the RPR ≥ 2 criterion has been applied inclusively rather than exclusively. It has not been consistently supplemented by strict scientific criteria of statistical and other forms of methodological adequacy. Only a few papers known to the author which report data that satisfy the RPR ≥ 2 criterion were excluded from the collection because of unusually flagrant violations of relevant methodological or reporting conventions.

Of the 125 instructional treatments that satisfied the RPR

≥ 2 criterion and were included in the collection as exhibits, 32 (26%) were identified as variants of a general category, Conventional Instruction (CI), and 88 (70%) as forms of Programmed Instruction (PI). In five other cases (4%), the high productivity identified by means of the RPR ≥ 2 criterion was not attributable to the instructional treatment per se but to the improvement of the effectiveness of the treatment, achieved by application of performance-based instructional design (PBID) procedures that are now routinely used by instructional designers in the development of effective forms of programmed instruction. In two of these cases the treatments modified by PBID were examples of conventional teaching (CT), in one case supplemented by conventional peer tutoring (CtCT). For the remaining three techniques in this category, the instructional treatments could not be categorized from information given in the evaluation reports. Their military context suggests that they were examples of programmed learning.

In all but a few of the comparisons represented in the collection, chiefly those in which both treatments were experimental procedures, the comparison treatment was not described, in some cases not even named in the report, but by implication it could be identified with some confidence as one of the very large number of complex instructional procedures in common use that are planned and/or spontaneously emitted by teachers. Such undescribed treatments, experimental or comparison, are arbitrarily categorized in this monograph as "conventional teaching" (CT). Four other categories of conventional instruction (CI), all experimental variants of CT and distinguished from it by more clearly specified features, were identified as augmented conventional teaching (ACT); conventional teaching supplemented by conventional (unprogrammed) tutoring (CtCT); and procedure modifications of conventional teaching (PMCT). The important PMCT category includes only two cases, but it may be pointed out that the categories that have been identified are not necessarily mutually exclusive. Most of the exhibits in the collection, CI or PI, could also be categorized in some sense as PMCT.

The general category, programmed instruction (PI), includes three variants. Two of these are programmed learning (PL), in which the learner follows the instructional program without assistance, e.g., without a teacher, and programmed teaching (PT), in which a teacher or tutor follows the program and in doing so provides instruction for one or more learners. The third subcategory of PI is partially programmed teaching (PPT), in which PT and PL are combined, separately or together, with CT. The third general category, PBID, was discussed above.

A second analysis of the collection examined estimated representative costs for 19 categories of instruction, including selected subcategories of those identified above and a few others of interest that did not qualify for the original collection. Given the rules and parameters that were utilized in making these estimates, the range of high to low estimates of instructional costs was found to be more than 2,000 to 1, from $23.15 per pupil-hour for tutoring by paid professional teachers to less than $.01 per pupil-hour for two other categories of instruction, one a form of conventional tutoring, the other a form of programmed group teaching.

Using the same parameters, instructional cost per pupil for conventional teaching in an 18-pupil classroom (the average of U.S. class size reported by USOE) was estimated to be $1.29. Estimated pupil-hour costs for five of the 19 categories of instruction for which estimates were made were higher than $1.29. Three of these exceeded this value by factors of three or more. Estimates for four other categories equalled $1.29, and estimates for those remaining were less than $1.29. Of the latter estimates, six were less than one-tenth the estimate for conventional classroom instruction when the instruction was unsupervised or was supervised by unpaid volunteers. When supervised by professional teachers, e.g., in a high-enrollment study hall or learning center, their estimated instructional cost was less than one-third that of conventional classroom instruction. Three of these six categories are represented in the collection by examples which satisfied the RPR ≥ 2 criterion for both teaching effectiveness and cost, a fourth for cost only. These four are programmed learning, conventional tutoring by unpaid tutors, programmed tutoring by unpaid tutors, and programmed group teaching by unpaid teachers.

Overview

The initial purpose of this monograph was to call attention to an extensive but informal collection of reports of experimental comparisons of two ways of achieving quantifiable instructional objectives. Each report indicated that one of the two procedures was more productive – i.e., more effective in that it achieved more instructional objectives represented by test items, was less costly, or both – than at least one other instructional procedure. This initial purpose has been accomplished. See Appendix I.

Unanalyzed, the collection of exhibits summarized in Appendix I is simply a list of 125 potential solutions to highly specific instructional problems, each defined by a particular set of instructional objectives, pupil and teacher characteristics, and other practical considerations. Such a set of N particular solutions to N particular problems is less useful, at least more difficult and costly to develop and implement, than a smaller set of general solutions to the same set of N problems. The analysis by categorization summarized above was an attempt to identify such a small set. This was done by identifying patterns of teaching or teaching management procedures that were common to more than one particular problem. This venture was notably less successful for conventional than for programmed instruction. The categories identified for conventional instruction were not very informative. "Augmentation," "modification of content," and "modification of procedures" may identify common patterns, but they do not provide clear rules for implementation of the general solutions they characterize. A search for clearer rules in most cases only led back to the original list of particular solutions (due in part, perhaps, to the relatively small number and great variety of the conventional solutions).

The common patterns found among solutions that involved programmed instruction were more informative, although the particular problems in this case were also varied. Collectively, they encompass essentially the entire range of subjects and levels of instruction in both technical training and general education. But the procedures represented by the three subcategories of PI have been operationally defined in ways that the CI procedures have not. They are operations that have been described in clear and maximally objective language in an extensive technical literature. Because of the simplicity and explicitness of these rules as they have been developed by instructional designers, they can be formulated as simple and explicit instructions – or programs – that can be followed precisely by relatively unqualified and minimally trained personnel, who are thereby enabled to teach themselves or others with minimal support from trained teachers. This feature of PI largely accounts for its potentially low cost.

The large number of exhibits classified as PI which satisfied the RPR ≥ 2 criterion for indices of effectiveness would seem to imply that the programming of instruction (alone) accounts for the teaching effectiveness of PI as well as its low cost. However, a more critical analysis indicates that this is not necessarily the case. There is good reason to believe, but insufficient evidence in the available sources of the PI exhibits to prove, that in all but a few examples of PI in the collection (e.g., Exhibits 34 and 105) two independent variables – *programming*, a teaching management procedure, and *performance-based instruction*, a teaching procedure – are confounded. With a few exceptions, what we initially categorized as PI may better be described as programmed PBI. If so, and if unprogrammed PBI (diagnostic teaching?) is sufficient to produce the high teaching effectiveness that in the collection is associated with programmed PBI, the general consequences for the improvement of teaching may be very great. The versatility of unprogrammed PBI is presumably no less than that of programmed PBI, and its basic simplicity should facilitate its incorporation into the existing arts of teaching. If, as this last analysis suggests, its effectiveness is also comparable to that demonstrated for programmed PBI, the increased use of unprogrammed PBI as a component of CI should be a significant move in the direction of excellence.

When appropriate and effective variants of CI are not being used, or the highly skilled teachers that are ordinarily required to implement CI methods are not available or affordable, the use of appropriate forms of programmed PBI (presumably with the aid of PBID during their development and use) should be seriously considered as a supplement or replacement for CI. The evidence presented in the "Incidental Finding" section of this report and other information suggests strongly that this is seldom being done now in general education, though it has been done for some time with many notable successes in the fields of military and industrial training.

In this monograph we have presented PBI (in programmed forms) as a psychotechnology of teaching. As a technology it is an application of modern scientific knowledge (of learning principles) to the solution of practical problems (of instruction), but in our opinion PBI is more than that, much older, and more basic. We see unprogrammed PBI as one of the very first forms of teaching (by the environment), i.e., learning by experience, which is said to be the best teacher, as the instructional analog of the principles of evolution which preserve and multiply biological structures on the basis of their performance in environmental test situations, and of operant conditioning, which does the same more quickly for the more evanescent units of behavior and thought. We see, hear, and read about unprogrammed PBI in practice, often in highly sophisticated forms, as a component of many of the traditional arts of teaching, and strongly suspect that the relative frequency with which this active and interactive method is used instead of passive oral teaching methods, such as the lecture, is the characteristic that most often distinguishes the work of the master teacher from that of the average and poor teacher. On the basis of the information available, we recommend that it be used more frequently by all teachers, except possibly the best, those who may be using it optimally now.

Appendix I
Exhibits 1-125

Appendix I

125 Exhibits of Teaching Procedures Which Satisfied the RPR $\geq$ 2 Criterion

This appendix provides a systematically annotated list of some 75 references to teaching methods or instructional management practices which have satisfied a strict quantitatively defined criterion of teaching productivity. To satisfy this criterion one procedure or treatment must be at least twice as effective, efficient, or cost-effective, or no more than half as costly, as another to which it is compared. The references contain information which identified 125 exhibits, each representing an instructional or management procedure which satisfied this criterion.

The information contained in the references is summarized under four headings: *Subject* or subjects taught, *Treatments* or procedures compared, *Measures* or indices of productivity used in the comparison, and *Results*, which are summarized in terms of a Relative Productivity Ratio (RPR) between two values of an index of productivity. The criterion that qualifies an instructional treatment as an exhibit is RPR $\geq$ 2.

Treatments that qualify as exhibits are ordered by category and, within each category, ordered alphabetically by source. All sources are also listed alphabetically by author or institution in the reference section of the monograph.

When two or more exhibits in the same category are reported in a single source, they are summarized in a single presentation, e.g., Exhibits 2 and 3, and Exhibits 106-120, and treatments corresponding to each of these exhibits are numbered in the left margin. Comparison treatments are not numbered. However, those comparison treatments which qualify as exhibits in different categories are summarized separately and are cross-referenced by exhibit number at the end of the source reference.

In some comparisons of two treatments, one of the two satisfied the RPR $\geq$ 2 criterion for one or more measures, the other for one or more different measures. This occurred several times when one or both of the two was a conventional control treatment and accounts for most of the exhibits in the CT category.

N*s* appearing under results refer to the number of comparisons reported in the exhibits which satisfied the RPR $\geq$ 2 criterion.

Table 3

Test Names and Acronyms Used in the Following Exhibits

CAT	California Achievement Test
CMM	Columbia Mental Maturity Scale
CTMM	California Test of Mental Maturity
Frostig	Frostig Personality Quotient
Gates	Gates Vocabulary Test
Gilmore	Gilmore Oral Reading Test
Ginn	Criterion test for Ginn Basal Reader Series
IOWA	Iowa Test of Basic Skills
ISRT	Iowa Silent Reading Test
ITPA	Illinois Test of Psycholinguistic Abilities
LOMD	Lincoln-Oseretsky Motor Development Test
MAT	Metropolitan Achievement Test
MLA	Modern Language Association Foreign Language Cooperative Test
Nelson	Nelson-Denny Test of Reading Ability
NYC	New York City Achievement Test
PPVT	Peabody Picture Vocabulary Test (IQ)
SAT	Stanford Achievement Test
SB	Stanford Binet Scale (IQ)
SOUTELE	Survey of Outcomes of Elementary Education (Tests constructed by the Philippine Ministry of Education and Culture to evaluate the elementary education system of the Philippines)
Spache	Spache Diagnostic Word Recognition Test
STEP	Sequential Test of Educational Progress
WISC	Wechsler Intelligence Scale for Children
WRAT	Wide Range Achievement Test

CT

Conventional Teaching

Exhibits 1-8

CT

EXHIBIT 1

SOURCE

Ellson, D.G.; L. Barber; T.L. Engle; and L. Kampwerth. "Programmed Tutoring: A Teaching Aid and a Research Tool," Experiment IV, *Reading Research Quarterly*, Fall 1965, pp. 77-127. (26) See also Exhibit 79.

SUBJECTS

Beginning reading, vocabulary

TREATMENTS

Data from Exhibit 79

Both groups in 3-hour kindergarten daily, for 12 days, with no exposure to print except that in movie titles (Control group in Exhibit 79). Experimental group (Group E_3 in Exhibit 79) taken out 30 minutes daily for traditional small-class instruction with the objective of teaching a reading vocabulary.

E: CT, Kindergarten procedures and curriculum plus reading vocabulary supplement, both taught traditionally

C: CT, Kindergarten procedures and curriculum, no exposure to print except that in movie titles

MEASURES

Gain in oral reading scores on a criterion test in which items were words taught in E-group treatment

RESULTS

E vs. C, RPR = 2.74

Exhibits 2, 3 **CT**

SOURCE

Hodges, W.L.; B.R. McCandless; and H.H. Spicker. *The Development and Evaluation of a Diagnostically Based Curriculum for Preschool Psycho-Socially Deprived Children*, Final Report, Project No. 50350, Grant No. OEG-32-24-0210-1011, USOE, Bureau of Research, Washington, D.C., December 1967. (46) See also Exhibit 12.

SUBJECTS

Kindergarten curriculum

TREATMENTS

Data from Exhibit 12
C_1: CT, Kindergarten control group
C_2: CT, At-home control group, parental treatment of disadvantaged rural children

MEASURES

SB-IQ, CMM-IQ, ITPA Language-age, Lincoln-Oseretsky Motor Development Scale total score

RESULTS

KC vs. AHC:	RPR range = 2.02 to 19.46	(N = 13)
AHC vs. KC:	RPR = 2.74	(N = 1)
AHC_1 vs. AHC_2*	RPR = 2.33	(N = 1)

*Two groups presumably given the same treatment

CT **Exhibit 4**

SOURCE

Karnes, M.B.; A.S. Hodgins; and J.A. Teska. *Research and Development Programs on Preschool Disadvantaged Children: Investigations of Classroom and At-Home Interventions*, Final Report, Vol. I, University of Illinois, Urbana, 1969, USDHEW, Office of Education, OEC6-10-235. (ERIC Document Reproduction Service No. ED 036 663) (50) See also Exhibits 13, 31, 76, 93.

SUBJECTS

Preschool curriculum

TREATMENTS

Data from Exhibit 93
C: CT, Traditional preschool curriculum and procedure
E_2: PT, Direct verbal method
E_3: PMCT, Community Integrated Method
E_4: ACT, Montessori Method

MEASURES

A. Peabody IQ gain
B. ITPA, auditory decoding gain
C. Met, number readiness, proportion in low normal category

RESULTS

	A	B	C
C vs. E_2:	RPR = 2.23	———	———
C vs. E_3:	RPR = 3.02	———	RPR = 3.00 (inverse RPR)
C vs. E_4:	RPR = 8.47	RPR = 4.23	———

(Total N = 5)

SOURCE

Malpass, L.F.; A.S. Gilmore; M.W. Hardy; and C.F. Williams. *Comparison of Two Automated Teaching Procedures for Retarded Children*, Cooperative Research Project No. 1267, University of South Florida, Tampa, Florida, 1963. (55) See also Exhibit 68.

SUBJECTS

Beginning reading, vocabulary

TREATMENTS

Data from Exhibit 68
C_1: CT, Traditional tutoring by certified teachers on 72-word list
C_2: CT, Traditional classroom procedure: "Teachers were given a list of the 72 programmed words and were informed of the nature of the study . . . although no control was exercised . . . all of them reported that they had spent at least some time each day presenting the words."
E_2: PL, Multiple-choice teaching machine

MEASURES

Gates Vocabulary Test, immediately and 30 and 60 days later

RESULTS

C_1 vs. C_2: RPR range = 2.62 to 14.04 (N = 5)
C_1 vs. E_2: RPR = 2.50, 55.00 (N = 2)
C_2 vs. E_2: RPR range = 3.14 to 27.00 (N = 3) Total N = 10

CT **Exhibit 7**

SOURCE

Malpass, L.F.; C.F. Williams; and A.S. Gilmore. *Programmed Reading Instruction for Culturally Deprived Learners*, MacDonald Training Center Foundation, Tampa, 1966. (ERIC Document Reproduction Service No. ED 011 065) (56) See also Exhibit 69.

SUBJECTS

Elementary reading, vocabulary

TREATMENTS

Data from Exhibit 69
E_2: CT, Traditional instruction plus word list in workbook form
C: CT, Traditional classroom instruction, same word list given to teacher

MEASURES

Criterion test scores (words read correctly), grade placement on Gates Test word list, criterion test of words in context, 30 day retention

RESULTS

E_2 vs. C: RPR range = 2.00 to 7.36 (N = 4)

Exhibit 8 **CT**

SOURCE

Weikart, D.P. *Relationship of Curriculum, Teaching, and Learning in Preschool Education*, High/Scope Educational Research Foundation, Ypsilanti, Michigan, 1971, National Leadership in Early Childhood Development in Washington, D.C. (ERIC Document Reproduction Service No. Ed 049 837) (96)

Weikart, D.P. *Early Childhood Special Education for Intellectually Subnormal and/or Culturally Different Children*, High/Scope Educational Research Foundation, Ypsilanti, Michigan, 1971, National Leadership in Early Childhood Development in Washington, D.C. (ERIC Document Reproduction Service No. ED 061 684) (95)

SUBJECTS

Preschool curriculum

TREATMENTS

E: CT, Preschool approaches ranging from "open framework" and child-centered to programmed teaching, but "emphasis was placed on making the curriculum flexible enough to gear classroom activities to each child's level of development." There are other indications that the experimental procedures were highly teacher-centered, and for this reason they are classified as conventional teaching.

C: CT, The control procedure is not specified. Incidental references suggest that it might be described as "no treatment," "custodial" preschool, or conventional at-home control treatment. The primary purpose of the experiment was to compare the effects of a variety of preschool treatments (E) with those of no preschool treatment (C).

MEASURES	RESULTS (E vs. C)	
SB-IQ, gains	RPR = 3.74, Spring 1st preschool year	
	RPR = 4.17, Spring 2nd preschool year	
	RPR = 2.74, Spring, end of 1st grade	
CAT Total battery gains	RPR = 2.43 gains, Spring 1st grade to Spring 3rd grade	
% overage in grade	RPR = 7.50	(Total N = 5)

ACT

Augmented Conventional Teaching

Exhibits 9-16

ACT **Exhibit 9**

SOURCE

Deutsch, M.; et al. *An Evaluation of the Effectiveness of an Enriched Curriculum in Overcoming the Consequences of Environmental Deprivation*, Institute for Developmental Studies, New York University, New York, 1965. (ERIC Document Reproduction Service No. ED 055 129) (19)

SUBJECTS

Enriched curriculum for ages 4-9

TREATMENTS

E: ACT, Diagnostic-directed enriched curriculum in preschool
C: CT, Traditional preschool (Head Start), and K-3 (school)

MEASURES	**RESULTS**
SBIQ gain	RPR = 9.81, 4.26, 3.95
PPVT gain	RPR = 2.03 (N = 4)

Exhibit 10 **ACT**

SOURCE

Feshback, Seymour; and others (not listed). *A Training, Demonstration and Research Program for the Remediation of Learning Disorders in Culturally Disadvantaged Youth*, Final Report, in two parts. Fernald School, Department of Psychology, UCLA. Project M7-200, California Department of Education, Division of Compensatory Education, 1969. (31) [ERIC Document Reproduction Service Nos. ED 034 237, ED 034 238 (#238 gives background on the Fernald method, #237 describes the evaluation study)]

SUBJECTS

Remedial academic and social skills

TREATMENTS

E_1: ACT, the Fernald method of individualized remediation taught by teachers trained in the methods, with special environment and facilities provided by the Fernald School.
E_2: PMCT, the Fernald method taught in a public school environment by public school teachers trained in the Fernald method by Fernald School personnel.
C: CT, traditional instruction in a public school environment by public school teachers with traditional training only.

MEASURES

CAT, mean gain in language, reading and arithmetic subtest scores; proportion of pupils achieving G.E. gains $\geq$ 1.0; mean improvement scores on (Sarason's) test anxiety scale for children.

RESULTS

E_1 vs. E_2, RPR range = 2.18 to 9.05 (N = 10)
E_1 vs. C, RPR range = 2.26 to 4.63 (N = 12)
C vs. E_1, RPR = 2.11* (N = 1)

*The RPR for the control treatment is not listed in the CT category since both the control group gain and the difference between group means were less than .5 score points (on the WISC Vocabulary subtest) and both group *n*s were less than 20. The E_2 procedure is also not listed, since it did not satisfy the RPR $\geq$ 2 criterion. The performance of this group was essentially the same as that of the control group.

Exhibit 11

SOURCE

Hillson, H.T. *Report on the Summer Session of the College Bound Program*, July - August 1967, Board of Education of The City of New York, 141 Livingston St., Brooklyn, NY 11201. (45)

SUBJECTS

College preparedness, mathematics, and reading (remedial)

TREATMENTS

E: ACT, Small classes, guidance, parental involvement, cultural enrichment
C: CT, Implicit control (predicted from national norms)

MEASURES

A: G.E. gains on SAT math computation subtest
B: G.E. gains, NYC Arithmetic Test, computation subtest

RESULTS

A: RPR = 2.50 (corrected for regression)
B: RPR $\simeq$ 5.00 (corrected for regression) (N = 2)

Exhibit 12 **ACT**

SOURCE

Hodges, W.L.; B.R. McCandless; and H.H. Spicker. *The Development and Evaluation of a Diagnostically Based Curriculum for Preschool Psycho-Socially Deprived Children*, Final Report, Project No. 5-0350, Grant No. OEG-32-24-0210-1011, U.S. Office of Education, Bureau of Research, Washington, D.C., December 1967. (46) See also Exhibits 2, 3.

SUBJECTS

Preschool curriculum

TREATMENTS

E: ACT, Experimental preschool — traditional preschool taught by a professional teacher plus aide, trained and helped (diagnosis and individualized lesson plans) by a "curriculum committee" of four experts and supported by consultants representing seven professions, plus special equipment and materials.

C_1: CT, Kindergarten Control (KC): traditional kindergarten

C_2: CT, Traditional at-home environment (AHC) in disadvantaged area

MEASURES

Gains in SB-IQ, CMM; PPVT; ITPA; LOMD

RESULTS

E vs. KC:	RPR range = 2.02 to 10.65	(N = 10)
E vs. AHC:	RPR range = 2.00 to 22.08	(N = 18)
KC vs. AHC:	RPR range = 2.02 to 19.46	(N = 13)
AHC vs. KC:	RPR = 2.74	(N = 1)
AHC_1 vs. AHC_2:	RPR = 2.33	(N = 1)

(Total N = 43)

ACT **Exhibit 13**

SOURCE

Karnes, M.B.; A.S. Hodgins; and J.A. Teska. *Research and Development Programs on Preschool Disadvantaged Children: Investigations of Classroom and At-Home Interventions*, University of Illinois, Urbana, 1969, USDHEW, Office of Education, OEC 6-10-235. (ERIC Document Reproduction Service No. Ed 036 663) (50) See also Exhibits 4, 76, 93.

SUBJECTS

Preschool curriculum

TREATMENTS

Data from Exhibit 93a
E_1: PT, Ameliorative
E_2: P.T, Direct Verbal
E_4: ACT, Montessori
C: CT, Traditional Preschool Control

MEASURES

Frostig PQ, ITPA subtests

RESULTS

E_4 vs. C: RPR range = 2.18 to 4.75 (N=6) (ITPA)
E_4 vs. E_1: RPR = 7.88 (N=1) (Frostig)
E_4 vs. E_2: RPR = 2.76 (N=1) (ITPA) (Total N=8)

Exhibit 14 **ACT**

SOURCE

The Rand Corporation. *Evaluation of Project R-3*, Administrative report of The Rand Corporation, Santa Monica, California, August 1968 (Program Title: Project R-3 in San Jose, California). (70)

SUBJECTS

Junior high mathematics

TREATMENTS

E: ACT, Traditional plus individualized instruction, special curriculum and facilities, increased staff, training, overnight trips, etc.
C: CT, Traditional

MEASURES

CAT, Grade equivalent gains, mathematics

RESULTS

RPR = 2.40 (boys only); RPR = 2.00 (boys, girls combined) (N=2)

Exhibit 15

SOURCE

Rapp, M.L.; and S.A. Haggart. *Evaluation of Project R-3, San Jose, California, 1971-1972.* Rand Corporation, Santa Monica, California, August 1972. (ERIC Document Reproduction Service No. ED 067 432) (71)

Project R-3: A Motivational Program Emphasizing Student Readiness, Subject Relevance and Learning Reinforcement Through Individualized Instruction, San Jose Unified School District, San Jose, California, 1972. (ERIC Document Reproduction Service No. ED 067 432) (69)

SUBJECTS

Reading, grades 8-9

TREATMENTS

E: ACT, Traditional with enriched curriculum similar to experimental treatment in Exhibit 14 plus simulation games
C: CT, Expected gains computed from pretest scores using norms

MEASURES	RESULTS
CAT, reading gains	RPR = 2.01 (1 year); 2.21 (2 years) (N = 2)
California Test of Basic Skills, proportion above grade level 1972 vs. 1970	RPR = 2.33 (Total N = 3)

Exhibit 16 **ACT**

SOURCE

Rollins, H.A.; B.R. McCandless; N. Thompson; and W.R. Brassel. "Project Success Environment: An Extended Application of Contingency Management in Inner-City Schools," *Journal of Educational Psychology*, 1974, vol. 66, pp. 167-178. (73)

SUBJECTS

"Behavior," math and reading achievement, grades 1-8

TREATMENTS

E: ACT, Behavior modification (described as "praise and ignore" and as "increased positive reinforcement and decreased punishment") was incorporated into conventional teaching (CT) and was augmented by an activity room containing "five academically-oriented interest stations" elaborately equipped and staffed by non-professional aides. Access to the activity room was described as an "activity reinforcer."
C: CT, Traditional

MEASURES	RESULTS
California Mental Maturity IQ gains	RPR range = 2.38 to 13.82 (N = 5)
California Achievement Test gains, G.E. reading, math	RPR_R = 3.44, RPR_M = 3.20 (N = 2)
Class disruptions ("behaviors")	RPR = 4.46 (inverse RPR) (N = 1) (Total N = 8)

CtCT

Conventional tutoring as supplement to Conventional Teaching

Exhibits 17-23

CtCT **Exhibit 17**

SOURCE

Cloward, R.D. "Studies In Tutoring," *Journal of Experimental Education*, 1967, vol. 36, no. 1. (16)

SUBJECTS

Tutoring of remedial reading, grades 4-5

TREATMENTS

E: CtCT, Traditional tenth- and eleventh-grade curriculum plus experience gained in tutoring of fourth- and fifth-graders. (Treatment of tutors whose gains satisfied criterion)
C: CT, Traditional tenth- and eleventh-grade curriculum

MEASURES

Iowa Silent Reading Test, comprehension subtest standard score gains
Total test, grade equivalent gains

RESULTS

(Tutors only) Comprehension standard score gains, RPR = 6.4;
Total test G.E. gains, RPR = 2.00 (Total N = 2)
No RPR $\geq$ 2 for tutees

Exhibit 18 **CtCT**

SOURCE

Fitz-Gibbon, C.T. *The Role Change Intervention: Experimental Data and a Design for Compensatory Education*, Center for the Study of Evaluation, UCLA Graduate School of Education, Los Angeles, California, 1976. (ERIC Document Reproduction Service No. ED 129 950) (32)

SUBJECTS

Addition of fractions, fourth-grade level

TREATMENTS

E: CtCT, Traditional plus traditional tutoring by eleventh-graders
C: CT, Traditional classroom ("competing control")

MEASURES

Criterion test scores

RESULTS

RPR = 2.01, 2.31 (N=2)

SOURCE

Klosterman, L.R. *The Effectiveness of a Diagnostically Structured Reading Program for Fourth-Grade Pupils Using Students Majoring in Elementary Education as Tutors*, University of Dayton, Ohio, 1968. (51) (ERIC Document Reproduction Service No. ED 028 910)

SUBJECTS

Reading, fourth-grade level

TREATMENTS

E_1: CtCT, Traditional tutoring, "diagnostically structured"
E_2: CtCT, Traditional small-group tutoring "diagnostically structured"
C: CT, Traditional classroom

MEASURES

Gain on California Reading Test, comprehension (September-January)

RESULTS

19 E_1 vs. C, RPR = 2.91
20 E_2 vs. C, RPR = 2.72 (N = 2)

Exhibit 21 **CtCT**

SOURCE

Morgan, R.F. and T.B. Toy. "Learning by Teaching: A Student-to-Student Compensatory Tutoring Program in a Rural School System and Its Relevance to the Educational Cooperative," *Psychological Record*, 1970, vol. 20, pp. 159-169. (63)

SUBJECTS

Spelling, arithmetic, grades 2-5

TREATMENTS

E: CtCT, Traditional schooling plus traditional tutoring of second- through fifth-graders by eighth- through twelfth-graders
C: CT, Traditional curriculum (tutors and tutees)

RESULTS

Tutees, RPR range = 2.06 to 2.96 (N = 5)
Tutors, RPR range = 2.00 to 4.30 (N = 5) (Total N = 10)

Interesting note: Evaluations of *tutors'* academic ability by the *tutor* and the *tutees' teacher* were significantly higher (p. < .01) than those made by the *tutors' homeroom teachers*.

CtCT **Exhibit 22**

SOURCE

Shaver, J.P.; and D. Nuhn. "The Effectiveness of Tutoring Underachievers in Reading and Writing," *The Journal of Educational Research*, 1971, vol. 65, pp. 107-112. (85)

Shaver, J.P. *Tutorial Students Two Years Later: A Report on the Logan-Cache Tutorial Center for Underachieving Readers and Writers*, Utah State Department of Public Instruction, Salt Lake City, Utah, June 1969. (ERIC Document Reproduction Service No. ED 046 961) (84)

SUBJECTS

Fourth-, seventh-, and tenth-grade reading and writing

TREATMENTS

E: CtCT, Traditional plus traditional tutoring
C: CT, Traditional classroom

MEASURES

A. STEP Test, gains in reading and writing
B. Proportion above, below potential

RESULTS

A. RPR range = 2.00 to 5.48 (N=6)
B. RPR range = 2.00 to 15.00 (N=29) (Total N=35)

Exhibit 23 **CtCT**

SOURCE

Smith, Mildred. *School and Home Program*, Flint, Michigan (U.S. Office of Education No. OE-37023), U.S. Government Printing Office, Washington, D.C., 1969. (89)

SUBJECTS

Reading, fifth grade

TREATMENTS

E: CtCT, Traditional school plus teacher-directed modification of home environment providing home-study materials and emphasizing simple specific tutoring activities as parental treatment
C: CT, Traditional school and parental treatment

MEASURES

Gains in Gates Reading Test scores, vocabulary, and comprehension

RESULTS

Vocabulary: RPRs = 4.57, 4.36; Comprehension: RPRs = 3.17, 4.38; Combined vocabulary and comprehension: RPRs = 2.18, 3.53 (N = 6)

CMCT

Content Modification in Conventional Teaching

Exhibits 24-30

CMCT **Exhibit 24**

SOURCE

Carter, J.L. *The Effect of a Group Language Stimulation Program Upon Negro Culturally Disadvantaged First-Grade Children,** Doctoral dissertation, University of Texas, 1966. Dissertation Abstracts International, 1967, vol. 27, p. 2870A (University Microfilms No. 67-3261). (12) Also, Dunn, L.M.; and J.O. Smith. *Manual: Peabody Language Development Kit*, Primary (experimental). George Peabody College for Teachers, Nashville, 1964. (22)

SUBJECTS

First-grade reading, language skills

TREATMENTS

E: CMCT, Closely supervised traditional teaching of small groups, using Peabody Language Development Kit as detailed lesson plans
C: CT, Traditional

MEASURES	RESULTS
S-B, IQ, MA gains	RPR = 2.33, 3.35
CTM (Total MA) gains	RPR = 3.46
Ammons and Ammons, Full Range Picture Vocabulary T	RPR = 4.75
ITPA (Psycholinguistic Abilities subtests)	RPRs = 3.45, 4.77, 6.28
Proportion assigned to special ed. classes	RPR = 8.00** (inverted RPR)

*Carter, J.L. and R.J. Capobianco. "A Systematic Language Stimulation Program — Revisited," *Education and Training of the Mentally Retarded*, April 1976, pp. 112-116. (Reports six-year retention data indicating RPRs for SBIQ and a reading test = 1.94 and 1.67 respectively.

**Report containing this RPR not seen; personal communication from the author. See also, Hawkridge, D.G. et. al. *A Study of Further Exemplary Programs for the Education of Disadvantaged Children*, Final Report. American Institute for Research, Palo Alta, CA, 1969, p. 22.

Exhibit 25 **CMCT**

SOURCE

Downing, J. *The I.T.A. Symposium; Research Report on the British Experiment With I.T.A.*, King, Thorne and Stace, Ltd., Sussex, England, 1967. (21)

SUBJECTS

Beginning reading in I.T.A. orthography

TREATMENTS

E: CMCT, Traditional instruction in I.T.A. orthography
C: CT, Traditional instruction in traditional orthography

MEASURES	RESULTS
Proportion of pupils who failed to "reach Primer III during instruction"	RPR = 2.02, 2.56 (inverted RPRs)
Proportion of pupils who completed Primer V during instruction	RPR = 2.07, 2.17, 4.54
Schonell Graded Word Reading Test, mean scores	RPR = 2.30, 2.72
Neale Analysis of Reading Ability, mean	RPR = 2.41 (Total N = 8*)

*Inclusion of the I.T.A. method in the collection might be questioned, since the experimental and control groups were not evaluated on the same (test) performance. Each group was evaluated for performance in the orthography used in its instruction. When both groups were tested on ability to read traditional orthography, results still favored the group taught in I.T.A. orthography but the highest value of RPR was 1.88.

CMCT

Exhibit 26

SOURCE

Fry, E.B. "First Grade Reading Instruction Using Diacritical Marking System, Initial Teaching Alphabet and Basal Reading System," *The Reading Teacher*, May 1966, pp. 27-30. (34)

SUBJECTS

First-grade reading

TREATMENTS

E_1: CT, Traditional teaching using Fry's Diacritical Marking System
E_2: CMCT, Traditional teaching using I.T.A. content

MEASURES

Scores on Fry's Phonetic Words Test (traditional orthography)

RESULTS

E_2 vs. E_1: RPR = 2.35 (N = 1)

Exhibits 27, 28 **CMCT**

SOURCE

Hayes, Robert B. "I.T.A. and Three Other Approaches to Reading in First Grade." In R.G. Stauffer, ed., *The First Grade Reading Studies: Findings of Individual Investigations*, International Reading Association, Inc., Newark, Delaware, 1967. (44)

SUBJECTS

First-grade reading

TREATMENTS

E_1: CMCT, (Scott, Foresman) Traditional approach plus PWP (Phonics and Word Power workbook)
E_2: CMCT, LIPP (Lippincott) Phonics plus audiovisual film strip (26)
E_3: CMCT, I.T.A. traditional method with I.T.A. content: "Early to Read"
E_4: CT, Basal traditional approach

MEASURES

Fry and Gates word lists, oral reading scores (high, medium, and low groups analyzed separately)

RESULTS

E_2 vs. E_1, E_4: RPR range = 2.26 to 7.59 (N = 7)
E_3 vs. E_1, E_4: RPR range = 2.87 to 9.85 (N = 3)

(Total N = 10)

CMCT **Exhibit 29**

SOURCE

Landa, L.N. *Algorithmization in Learning and Instruction*. Educational Technology Publications, Englewood Cliffs, New Jersey, 1974. (53)

SUBJECTS

Russian grammar, USSR equivalent of U.S. seventh- and eighth-grade levels

TREATMENTS

E: CMCT, Traditional method, algorithmized content
C: CT, Traditional method, traditional content

MEASURES	RESULTS
Objective criterion test scores	RPR = 6.61, 6.16, 6.11, 5.00 (N = 4)
Proportion exceeding criterion cut-off	RPR = 2.00, 18.18 (N = 2) (Total N = 6)

Exhibit 30 CMCT

SOURCE

Reid, H.C. and L. Beltramo. "Teaching Reading to the Low Group in the First Grade." In R.G. Stauffer, ed., *The First Grade Reading Studies: Findings of Individual Investigations*. International Reading Association, Inc., Newark, Deleware, 1967. (72)

SUBJECTS

Reading, grade 1

TREATMENTS

Seven experimental "methods" taught traditionally with following contents: 1) Language, 2) Letter sounds, 3) Literature, 4) "Skills" 5) Combined 1 and 2, 6) Combined 1 and 3, 7) Combined 1 and 4

E_1: CMCT, "Language method. . . . Elementary English materials . . . selected for their emphasis on the combined skills of listening, writing, speaking, and reading. . . . "

E_2: CMCT, "Letter-sounds method. . . . Recognition of the letters of the alphabet and their sounds and the use of context clues. . . . "

MEASURES

Proportion of comparisons favoring a given method in a paired comparison procedure (seven methods on five "Stanford Achievement subtests")

RESULTS

E_1 vs. E_2: RPR = 2.00 (N = 1)

PMCT

Procedural Modifications of Conventional Teaching

Exhibits 31-32

PMCT **Exhibit 31**

SOURCE

Karnes, M.B.; A.S. Hodgins; and J.A. Teska. *Research and Development Programs on Preschool Disadvantaged Children: Investigations of Classroom and At-Home Interventions,* Final Report, University of Illinois, Urbana, 1969, USDHEW, Office of Education, OEC 6-10-235. (ERIC Document Reproduction Service No. ED 036 663) (50) See also exhibit 93.

SUBJECTS

Preschool curriculum

TREATMENTS

E_3: PMCT, Community-integrated method. Traditional instruction with class integrated socioeconomically to provide advantaged peer models for disadvantaged children. (Only disadvantaged children represented in CI group data.)
E_1: PT, Ameliorative method
E_4: ACT, Montessori method

MEASURES

Peabody IQ, Met readiness, Frostig PQ, ITPA subtests

RESULTS

E_3 vs E_1: RPR = 8.00
E_3 vs. E_4: RPR range = 2.06 to 5.15 (N = 3)

Exhibit 32 **PMCT**

SOURCE

Rosenthal, R. and L. Jacobson. "Teachers' Expectations: Determinants of Pupils' IQ Gains," *Psychological Reports*, 1966, vol. 19, pp. 115-118. (79)

SUBJECTS

Grades 1-2, elementary curriculum

TREATMENTS

E: PMCT, Traditional teaching of certain pupils* when the teacher had been told that those pupils scored in the upper 20% on the "Harvard Test of Inflected Acquisition" and that their scores predicted an academic "spurt" in the coming year. (Approximately 20% of the pupils in each class were so identified. No other special information was given about these or the other pupils.)

C: CT, Traditional teaching of all other pupils in the same classes*

MEASURES

IQ gains on TOGA, a test of "verbal and nonverbal intelligence"

RESULTS

	Experimental		*Control*		*Difference*		
Grade	*N*	*Gain*	*N*	*Gain*	*in gain*	*RPR*	*P*
1	7	27.4	48	12.0	+ 15.4	RPR = 2.28	< .002
2	12	16.5	47	7.0	+ 9.5	RPR = 2.36	< .02
							(N = 2)

*E and C groups were exclusive 20% and 80% random samples from the same population.

PL

Programmed Learning

Exhibits 33-75

PL **Exhibit 33**

SOURCE

Adams, E.N. "Evaluation of the German CAI Lab." In R.C. Atkinson and H.A. Wilson, eds., *Computer-Assisted Instruction*. New York: Academic Press, 1969, pp. 205-209. (1) (See also Rosenbaum, *PMI* (78) p. 23ff.)

SUBJECTS

German language, college level

TREATMENTS

E: PL, Traditional audio-lingual instruction (CT) plus non-oral, non-aural computer assisted instruction (PL) involving reinforcement of correct responses and error-prompting
C: CMCT, Traditional audio-lingual instruction (CT) plus language laboratory

MEASURES

Modern Language Association Aptitude Test, reading and writing: proportion below control group median

RESULTS

RPR = 3.33 (inverse RPR) (N = 1)

Note: Results on MLA tests of speaking and listening were essentially the same for both groups.

Exhibit 34 **PL**

SOURCE

Brewer, I.M. "Recall, Comprehension and Problem Solving: Evaluation of an Audiovisual Method of Learning Plant Anatomy," *Journal of Biological Education*, 1974, vol. 8, pp. 101-112. (6)

SUBJECTS

College level plant anatomy

TREATMENTS

E: PL, Semi-programmed, independent study using audiotape, textbook, and lab materials.
C: CT, Traditional lecture/lab — earlier sections of "same" course

MEASURES

Percent of passing scores (scores $\geq$ 70); percent of failures (scores $<$ 50)

RESULTS

Percent passes: RPR = 2.74; percent failures (inverse RPR): RPR = 2.10 (N = 2)

Exhibits 35-37

SOURCE

Briggs, J.F. "Military and Governmental Applications: Programmed Instruction Breakthrough in Air Force Training?" In G.D. Ofiesh and W.C. Meierhenry, eds., *Trends in Programmed Instruction: Papers from First Annual Convention of The National Society for Programmed Instruction*, Department of Audiovisual Instruction, National Education Association of the United States, Washington, D.C., 1964. (7)

SUBJECTS

Technical skills and knowledge

TREATMENTS

E: PL, Programmed learning
C: CT, Conventional classes

MEASURES

Criterion test scores; instructional time; efficiency (performance/time)

RESULTS

	Performance Test Scores	*Instructional Time (Inverse R)*	*Efficiency*	
Hydraulic and pneumatic principles	RPR = 1.20	6.00	7.20	
Introductory radar course	RPR = 1.00*	3.00	3.00	
Use of hand tools	RPR = 1.33	1.67	2.22	(N = 5)

*No data. Assumes control group performance equal to experimental group performance.

Exhibit 38

PL

SOURCE

Brink, R. "Application of Audio-Lingual Programming to Industrial Training." In G.D. Ofiesch and W.C. Meierhenry, eds., *Trends in Programmed Instruction: Papers from First Annual Convention of the National Society for Programmed Instruction*, Department of Audiovisual Instruction, National Education Association, Washington, D.C., 1964. (8)

SUBJECTS

Performance as telephone operators

TREATMENTS

E: PL, Programmed learning (tapes), instructor manuals
C: CT, Performance of previous classes, traditional

MEASURES

Proportion passing scores; proportion perfect scores; instructional time; efficiency

RESULTS

Scores	*Time*	*Efficiency*	
% passing scores: RPR = 1.52	1.67 (inverse RPR)	RPR = 2.54	
% perfect scores: RPR = 1.85		RPR = 3.09	(N = 2)

PL

Exhibit 39

SOURCE

Cavanaugh, P.; C. Thornton; and R.G.T. Morgan. "The Autotutor and Classroom Instruction: Three Comparative Studies," *Programmed Learning*, The British European Airways Study, 1965, vol. 2, pp. 118-125. (13)

SUBJECTS

Airplane loading computations

TREATMENTS

Two experiments: A. Heterogeneous subjects (employees); B. Selected subjects (apprentices)
E: PL, Programmed learning using autotutor
C: CT, Same content, lecture form

MEASURES

Criterion test score gains, instructional time, efficiency

RESULTS

Test Score Gains	*Instructional Time*	*Efficiency*	
Group A: RPR = 1.33	1.65 (inverse RPR)	2.19	
Group B: RPR = 1.05	2.21 (inverse RPR)	2.33	(N = 3)

Exhibit 40 **PL**

SOURCE

Coleman, L.L. "An Experiment in Programming the Care and Use of Aircraft Mechanics' Handtools." In G.D. Ofiesch, and W.G. Meierhenry, eds., *Trends in Programmed Instruction: Papers from the First Annual Convention of the National Society for Programmed Instruction*, Department of Audiovisual Instruction, National Education Association of the United States, Washington, D.C., 1964. (17)

SUBJECTS

Care and use of tools

TREATMENTS

E: PL, Automated 302-frame program, including frames requiring use of tools on training devices
C: CT, Conventionally instructed course

MEASURES

Criterion-based written and performance test gains, instructional time, efficiency

RESULTS

	Gains	*Time*	*Efficiency*	
Written Test	RPR = 1.69	1.54	2.06	
Performance Test	RPR = 1.31		2.02	(N = 2)

SOURCE

Davies, Ivor K. "Programmed Learning in the United States Air Force," *Programmed Learning*, November 1964, pp. 113-124. (18)

SUBJECTS*

Use of oscilloscope, typing an Air Force letter, aircraft load planning, qualitative and quantitative fuel control, preventive dentistry, maintenance and inspection of missiles, use of common hand tools, and technical Air Force terminology for foreign students, etc.

TREATMENTS

E: PL, Programmed learning, developed with instructional design principles
C: CT, Traditional

MEASURES

Criterion-based test scores, proportion scores "good" or "excellent," instructional time.

RESULTS

In 10 of 43 studies reported instructional time was reduced by 50% or more (RPR $\geq$ 2). For these, mean RPR = 2.60, RPR range = 2.00 to 5.00 (N = 10). In 17 of the 43 studies reported, efficiency was doubled or better (RPR $\geq$ 2). For these, mean RPR = 2.71, RPR range = 2.00 to 5.25 (N = 17). In 1 of the 43 studies reported, proportion of students with scores classified as "good" or "excellent," RPR = 5.00 (N = 1). Others may have satisfied the RPR $\geq$ 2 criterion for performance scores.

(Total = 28)

*Subjects listed are examples of the subjects taught in 43 studies evaluated. Davies's data were presented graphically only. Subjects taught were not indicated for data points.

Exhibit 58

PL

SOURCE

Eurich, N.; and B. Schwenkmeyer. *Great Britain's Open University: First Chance, Second Chance, or Last Chance?* Paper No. 5, New York Academy for Educational Development, 437 Madison Avenue, 1971, p. 31. (30)

Smith, P.J. "Britain's Open University: Everyman's Classroom," *Saturday Review*, April 1, 1982, pp. 40-50. (90)

SUBJECTS

University degree curricula in mathematics, science, humanities, social science, and technology

TREATMENTS

E: PL, Self-instruction, primarily from programmed texts and other books (approximately 85%), supplemented by TV and radio, plus one week per year of intensive traditional instruction, and tutoring (approximately 15% of instruction)
C: Traditional instruction in other British universities

MEASURES AND RESULTS

*Effectiveness**	*Operating Costs*	*Cost to Students*
RPR = 1.00	RPRs = 3.10 to 3.80 (Inverse RPRs)	RPR = 5.00 (inverse RPR)

*Based on apparent consensus that graduates are academically equivalent to those of other British universities (though, on entry, many O.U. students had been, in effect, excluded from the British university system on the basis of low test scores).

Exhibits 59-63

SOURCE

Harris, R.F. "Programmed Instruction at Chanute AFB, Illinois." In G.D. Ofiesch and W.C. Meierhenry, eds., *Trends in Programmed Instruction: Papers from the First Annual Convention of the National Society for Programmed Instruction*, Department 8, Audiovisual Instruction, National Education Association of the United States, Washington, D.C., 1964. (41)

SUBJECTS

Academic, technical, adult level (See table of results)

TREATMENTS

E: PL, Programmed Learning (Programmed Instruction Packages)
C: CT, Traditional course

MEASURES

Scores on criterion tests, gains, instructional time, efficiency

RESULTS

Subjects	*Scores*	*Gains*	*Time (Inverse RPR)*	*Efficiency*	*N*
Pitot Static Systems	1.28		2.21	2.83	
		1.53	2.21	3.38	4
Basic Hydraulic & Pneumatic Systems	1.09		3.20	3.49	
		1.25	3.20	4.00	4
How to Study	1.53		1.69	2.59	
		1.59	1.69	2.69	2
Principles of Learning	1.61		2.09	3.36	
		2.06	2.09	4.31	5
Aerodynamics	1.03		1.84	1.89	
		1.26	1.84	2.32	1
				Total N =	16

Exhibit 64

PL

SOURCE

Johnson, K.A., et al. *Comparison of Conventional and Programmed Instruction in Teaching Communication Procedures*, Naval Personnel Research Activity, San Diego, California. Report No. NPRA-STB-67-20, Project Pf 17034001, May 1967. (48) Data obtained from abstract.

SUBJECTS

Military communication (radio code operator course)

TREATMENTS

E: PL, Programmed learning
C: CT, Traditional lecture-discussion

MEASURES

Instructional time

RESULTS

RPR_1 = 2.07 (inverse RPR)   N = 1

PL **Exhibits 65, 66**

SOURCE

Knight, M.A.G. "The Autotutor and Classroom Instruction: Three Comparative Studies," #2, The Royal Air Force Study, *Programmed Learning*, 1964, vol. 1, p. 89ff. (52)

SUBJECTS

Trigonometry (adults in radio engineering school)

TREATMENTS

Exp. I: E_1: PL, Autotutor device (teaching machine) and film, "Foundations of Trigonometry"
C_1: CT, Classroom lectures (11 hr. course)

Exp. II: E_2: PL, Teaching machine and film plus private study
C_2: CT, Lecture course plus private study

MEASURES

Instructional time (E & C test scores almost identical but favoring E groups)

RESULTS

Exp. I: RPR = 2.00; Exp. II: RPR = 2.57 (N=2)

Exhibits 67, 68

PL

SOURCE

Malpass, L.F.; A.S. Gilmore; M.W. Hardy; and C.F. Williams. *Comparison of Two Automated Teaching Procedures for Retarded Children*. Cooperative Research Project No. 1267, University of South Florida, Tampa, Florida, 1963. (55) See also Exhibits 5, 6.

SUBJECTS

Beginning reading, vocabulary

TREATMENTS

E_1: PL, Three-multiple choice teaching machine
E_2: PL, Typewriter keyboard machine
C_1: CT, Tutoring
C_2: CT, Traditional classroom

MEASURES

Number of programmed words, unprogrammed words, spelling words, and retention; Gates Word Recognition Test scores

RESULTS

67 E_1: Multiple choice: RPR range = 2.00 to 19.63 (N = 12)
68 E_2: Keyboard: RPR range = 2.12 to 44.67 (N = 27)
C_1: Tutoring: RPR range = 2.50 to 55.00 (N = 7)
C_2: Classroom: RPR range = 2.40 to 21.00 (N = 3)

(Total N = 49)

PL **Exhibit 69**

SOURCE

Malpass, L.F.; C.F. Williams; and A.S. Gilmore. *Programmed Reading Instruction for Culturally Deprived Learners*, The MacDonald Training Center Foundation, Inc., Tampa, Florida, 1966. (ERIC Document Reproduction Service No. ED 011 065) (56) See also Exhibit 7.

SUBJECTS

Reading for culturally deprived learners, word recognition

TREATMENTS

E_1: PL, Traditional plus teaching machine
E_2: CT, (Workbook) traditional including workbook
C: CT, Traditional

MEASURES

Programmed words gained
Programmed words, 30-day retention
Gates Paragraph Reading gains
Gates Paragraph Reading, G.E. gains
Gates Paragraph Reading, programmed words, gains

RESULTS

E_1 vs. C: RPR range = 2.07 to 6.82, (N = 5)
E_2 vs. C: RPR range = 2.00 to 7.36, (N = 4)
(Total N = 9)

Exhibits 70, 71 **PL**

SOURCE

Potar, Nuanchan. *Project RIT (Reduced Instructional Time)*, Project Report #2, SEAMEO Regional INNOTECH Center, College of Education, University of the Philippines, Quezon City, Philippines. (68)

SUBJECTS

Elementary curriculum: two experiments, each with its own CT control group
Exhibit 70: Thai language content
Exhibit 71: health content

TREATMENTS

E_1: PL, Language content: Traditional introduction plus programmed learning in self-instructional games
E_2: PL, Health content: Programmed learning in programmed booklets, "comic book" form
C_1 and C_2: CT, Traditional instruction of same subjects

MEASURES

Criterion test scores, instructional time, efficiency (scores/time)

RESULTS

	Scores	*Time*	*Efficiency*	
Language Exp.:	RPR = 3.18	2.89 (inverse RPR)	9.19	
Health Exp.:	RPR = 2.60	12.86 (inverse RPR)	33.44	(N = 6)

Exhibits 72, 73

SOURCE

Ruddell, R.B. "Reading Instruction in First Grade with Varying Emphasis on the Regularity of Grapheme-Phoneme Correspondences and the Relation of Language Structure to Meaning." In R.G. Stauffer, ed., *The First-Grade Reading Studies: Findings of Individual Investigations*, International Reading Association, Inc., Newark, Delaware, 1967. (80)

SUBJECTS

E_1: CT, Traditional, Sheldon Basal Series
E_2: PL, Buchanan (Basal plus phonics program approach)
E_3: CMCT, Treatment E_1 modified to stress language structure related to meaning
E_4: PL, Treatment E_2 supplemented by language structure related to meaning

MEASURES

Scores on MAT, regular word identification

RESULTS

E_2 vs. E_3: RPR = 2.95
E_4 vs. E_3: RPR = 3.25 (N = 2)

Exhibit 74 **PL**

SOURCE

Rushton, E.W. *Programmed Learning: The Roanoke Experiment*, Encyclopedia Britannica Press, Chicago, 1965. (81)

SUBJECTS

Ninth-grade algebra

TREATMENTS

E: PL, (teaching machine) (taught to lower two-thirds of eighth-grade class, those not qualified to enter ninth-grade algebra)
C: CT, Traditional class (ninth-grade subjects: instructional time 1 year)

MEASURES

Instructional time, scores on Langton first year algebra test, form BM

RESULTS

Instructional time: RPR = 2.00 (inverse RPR) (N = 1)

Note: Test scores for 41% of E-group pupils "surpassed the average score made by the ninth-grade students."

PL **Exhibit 75**

SOURCE

Smith, E.A. and J. Quackenbush. "Devereux Teaching Aids Employed in Presenting Elementary Mathematics in a Special Education Setting," *Psychological Reports*, 1960, vol. 7, pp. 333-336. (88)

SUBJECTS

Mathematics: taught to slow learners who scored between third- and sixth-grade levels

TREATMENTS

E: PL, Traditional plus access to teaching machine math program
C: CT, Traditional previous year

MEASURES

Gains on CAT arithmetic grade equivalent

RESULTS

RPR = 2.68 (N = 1)

PT
Pt

Programmed Teaching (PT)
or
Programmed tutoring (Pt)

Exhibits 76-104

PT **Exhibit 76**

SOURCE

Bereiter, C. and S. Engelmann. *The Effectiveness of Direct Verbal Instruction on IQ Performance and Achievement in Reading and Arithmetic*, Academic Preschool, Champaign, Illinois, 1966. (ERIC Document Reproduction Service No. ED 030 496) (3). See also Exhibit 93 for additional RPRs for the Direct Verbal method.

SUBJECTS

Preschool mathematics, reading

TREATMENTS

E: PT, Direct verbal method, small groups, rapid-fire recitation, individualized response and feedback. Disadvantaged group measured after one year and two years of treatment. Advantaged group measured after two years of treatment.
C_1: CT, Traditional preschool, small group, disadvantaged subjects
C_2: ACT, Montessori method, small group, advantaged (middle class) subjects

MEASURES

Disadvantaged group: SB-IQ gains
Advantaged group: Wide Range Achievement Test, reading and arithmetic achievement, grade equivalents. IQ post-test but no pretest or gain data.

RESULTS

Disadvantaged: E vs. C_1: RPR = 2.12, 5.04
Advantaged: E vs. C_2: Reading Ach., RPR = 3.28; Arithmetic Ach., RPR = 2.40

Exhibit 77 **Pt**

SOURCE

Dorval, B.; S. Wallach; and M. Wallach. "Field Evaluation of a Tutorial Reading Program Emphasizing Phoneme Identification Skills," *The Reading Teacher*, April 1978, pp. 784-790. (20)

SUBJECTS

First-grade reading

TREATMENTS

E: Pt, Traditional plus programmed tutoring in phonics
C_1: CT, Traditional
C_2: CtCT, Traditional plus traditional teacher-directed tutoring

MEASURES

Score, Spache Diagnostic, word recognition test

RESULTS

E vs. C_1: RPR = 2.14; E vs. C_2: RPR = 3.59; (N=2)

Pt **Exhibit 78**

SOURCE

Ebersole, E.H. *A Summary of Reading Test Scores of Soto Street School in Los Angeles from 1966-67 to 1971-72*, Eberson Enterprises (now defunct), 3414 E. California Blvd., Los Angeles, 1973. (23)

SUBJECTS

Reading, grades 1-6

TREATMENTS

E_{1-5}: Pt, Traditional classroom teaching plus Pt, evaluated in five successive years. Same conditions repeated with appropriate modifications in successive classes. (May be PBID, but not explicit.)
C_1: Pt, Traditional plus experimental Pt in first grade
C_2: CT, Traditional plus no tutoring (first grade only)

MEASURES

Proportion of pupils in stanines 4-9 on "a Stanford reading test"

RESULTS

E_{1-5} vs. C_1: RPR range = 3.24 to 20.25 (N = 18)
E_{1-5} vs. C_2: RPR range = 2.69 to 5.54 (N = 18)
E_{1-5} vs. other E_{1-5}: RPR range = 2.03 to 3.68 (N = 14)
C_1 vs. C_2: RPR = 3.25 (N = 1) (Total N = 51)

SOURCE

Ellson, D.G.; Larry Barber; T.L. Engle; and Leonard Kampwerth. "Programmed Tutoring: A Teaching Aid and a Research Tool," *Reading Research Quarterly*, Vol. 1, No. 1, Fall, 1965. (26). Experiment IV, p. 88. See also Exhibit 1.

SUBJECTS

First-grade reading, vocabulary

TREATMENTS

All groups in three-hour kindergarten daily, no exposure to print except that in 30-minute experimental treatments and (for all groups) movie titles

E_1: Pt, Vocabulary taught individually with sight-reading program in 30-minute sessions

E_2: Pt, Same vocabulary taught by E_1 and E_3 procedures in alternate 30-minute sessions

E_3: CT, Same vocabulary taught by traditional classroom procedures in groups of eight, 30 minute sessions

C: CT, Control procedure, three-hour traditional kindergarten procedures only, no exposure to print except in movie titles

MEASURES

Mean gain on criterion test, sight reading vocabulary

RESULTS

E_1 vs. C, RPR = 4.98 (N = 1)
E_2 vs. C, RPR = 5.70; E_2 vs. E_3: RPR = 2.08 (N = 2)
E_3 vs. C, RPR = 2.74 (see Exhibit 1) (Total N = 4)

Pt **Exhibit 81**

SOURCE

Ellson, D.G.; L. Barber; and L. Kampwerth. "Programmed Tutoring: A Teaching Aid and a Research Tool," *Reading Research Quarterly*, Fall 1965. (26). Experiment VII.

SUBJECTS

First-grade reading vocabulary (taught to older retardates in academic school who were reported to be nonreaders).

TREATMENTS

E: Pt, Programmed tutoring with revision of sight-reading program used in Experiment IV (see E_1 in Exhibit 79) 20-minute sessions
C: CT, Traditional classroom instruction, reading content only, 30-minute sessions (content same as in E-group treatment)

MEASURES

A. A 10% random sample of Gates Vocabulary test words
B. List of 105 programmed words, to be read orally
C. List of 49 sentences from teaching material constructed from words in B.

All groups scored for gains in number of different words read correctly

RESULTS

Test A: RPR = 4.27
Test B: RPR = 8.61
Test C: RPR = 20.49 (Total N = 3)

Exhibit 82 **Pt**

SOURCE

Ellson, D.G. *The Effect of Programmed Tutoring in Reading on Assignment to Special Education Classes: A Follow-Up of Four Years of Tutoring in the First Grade*, Final Report, Grant No. OEG 9-242178-4149-032, U.S.O.E., Bureau of Education for the Handicapped, Center for Research and Development for Handicapped Children, Indiana University (Mimeo) July 1971. (25)

SUBJECTS

Reading, first-grade level

TREATMENTS

E: Pt, Traditional plus programmed reading tutorial (sightreading, word analysis and comprehension) in first grade, 15 minutes daily
C: CT, Traditional first-grade instruction, no tutoring

MEASURES

A. Proportion of non-readers, i.e., proportion with scores at chance level or below on Ginn Pre-primer and Primer Achievement Tests, combined
B. Proportion below proper grade placement or in special education classes one year later
C. Proportion in special education classes one and two years later

RESULTS

E vs. C:

Measure A: RPR = 6.96 (inverse RPR)
Measure B: RPR = 3.24 (inverse RPR)
Measure C: RPR = 3.80, RPR = 4.68 (inverse RPR) (Total N = 4)

Pt

Exhibit 83

SOURCE

Epstein, L.E. *The Effects of Intra-Class Peer Tutoring on the Reading Performance of Mildly Handicapped Children*. Doctoral dissertation, Indiana University, 1975. (29)

SUBJECTS

Reading (word recognition); mildly handicapped; elementary level

TREATMENTS

E: Pt, Programmed peer tutoring 15 minutes daily
C: CT, Traditional (learning disability curriculum)

MEASURES

Gains on criterion test (words read orally)

RESULTS

RPR = 2.59 (N = 1)

Exhibit 84 **Pt**

SOURCE

George, J.E. and Linda S. Pugh. *Dropout Prevention Project*, University of Missouri, Kansas City, Faculty Research Grant Study. Final Report, August 1974. (Program Title: Tutor-Student System) (37)

SUBJECTS

Remedial reading, comprehension, grades 10-11

TREATMENTS

E: Pt, Traditional plus tutor-student system in reading
C: CT, Traditional (English or reading classes)

MEASURES

Gains in G.E., Gilmore Oral Reading Test, comprehension

RESULTS

RPR = 3.57 (tutees) (N = 1)

Exhibits 85-87

SOURCE

Hamblin, June A. and Robert L. Hamblin. "On Teaching Disadvantaged Preschoolers to Read: A Successful Experiment," *American Educational Research Journal*, Washington, D.C., Spring 1972. (39)

SUBJECTS

Beginning reading (I.T.A. in preschool)

TREATMENTS

I.T.A. primers plus programmed tutoring using Language Master and:
E_1: Pt, Exchangeable tokens for reading correctly, peer tutors
E_2: Pt, Exchangeable tokens for reading correctly, adult tutors
E_3: Pt, Exchangeable tokens for attendance, peer tutors
E_4: Pt, Exchangeable tokens for attendance, adult tutors

MEASURES

Number of symbols, words, and books read correctly

RESULTS

E_1 vs. E_2, E_4: RPR range = 2.02 to 3.91 (N = 4)
E_2 vs. E_4: RPR = 2.92 (N = 1)
E_3 vs. E_4: RPR range = 2.14 to 2.26 (N = 3) (Total N = 8)
E_4 vs. others: No RPR $\geq$ 2

Exhibit 88 **Pt**

SOURCE

Harrison, G.V. *The Effects of Professional and Non-Professional Trainers Using Prescribed Training Procedures on the Performance of Upper Grade Elementary Student Tutors*, University of California, 1969. (Doctoral dissertation, Order No. 70-8147) (42)

SUBJECTS

Reading, elementary level

TREATMENTS

E: Pt, Partially programmed tutoring by tutors trained in "structured tutoring" by trained trainers
C: CT, Tutoring by comparable tutors trained by untrained trainers

MEASURES

"Criterion test" (reading by tutees)

RESULTS

RPR = 2.60 (N = 1)

Note: This summary based on abstract only. The study is interpreted as a comparison of programmed and conventional tutoring as defined by training of tutor-trainers.

Pt Exhibits 89-92

SOURCE

Hofmeister, A.M. *Project TELEPAC: A Prototype Educational Service Delivery Model for Severely Handicapped Children in Rural and Remote Areas*, Technical Report No. 13, Utah State University, Exceptional Child Center Outreach and Development Division, Logan, Utah, 1976. (47)

SUBJECTS

Academic and self-help skills in handicapped children

TREATMENTS

E: Pt, Programmed tutoring by parents with aid of instructional packages and professional consultation on telephone (For content see Results below.)
C: CT, Traditional parental training of tutees

MEASURES

Percent gain in scores on criterion-based tests.

RESULTS

Academic skills: RPRs = 10.83, 4.00 (N = 2)
Self-help skills: RPRs = 3.40, 22.87 (N = 2)
All programs combined (9 programs): RPR = 2.85 (N = 1) Total N = 5

Exhibit 93a **PT**

SOURCE

Karnes, Merle B.; A.S. Hodgins; and J.A. Teska. *Research and Development Programs on Preschool Disadvantaged Children: Investigations of Classroom and At-Home Interventions*, Final Report, University of Illinois, Office of Education, Urbana, Illinois, 1969, OEC 6-10-235. (ERIC Document Reproduction Service No. ED 036 663) (50) See also Exhibits 4, 13, 31, 76.

SUBJECTS

Preschool curricula

TREATMENTS

E_1: PT, Ameliorative method (Karnes), traditional plus semi-programmed, verbal content in meaningful game formats
E_2: PT, Direct verbal method (Bereiter and Engelmann): highly structured rapid-fire oral drill in language, reading, and arithmetic
E_3: PMCT, Community integrated method, traditional with classes integrated socioeconomically to provide advantaged peers for disadvantaged children
E_4: ACT, Montessori method preschool
C: CT, Traditional preschool or kindergarten

MEASURES

SBIQ; Peabody IQ; Metropolitan Reading Readiness; Frostig PQ; ITPA; Gains, losses and proportions

RESULTS

(Cases of RPR $\geq$ 2 in which the given method was superior to another method)

	Range of RPRs	*N*
E_1: PT, (AM)	2.10 to 6.50	20
E_2: PT, (DV)	2.03 to 8.40	15
E_3: PMCT, (C-I)	2.06 to 8.00	4
E_4: ACT, (M)	2.18 to 7.88	8
C: Traditional (CT)	2.23 to 8.47	5
	Total N =	52

Exhibit 93b

SOURCE

Karnes, M.B.; et al. *A Follow-Up of Three of the Five Preschool Interventions: Evaluations Over Three Years*. P. 147ff in source-reference for 93a. (49) See also Exhibits 4, 13, 31, 76.

SUBJECTS

Preschool curriculum (effects on first-grade IQ gains, reading and mathematics achievement).

TREATMENTS

E_1: PT, Ameliorative (Karnes)
E_2: PT, Direct verbal (Bereiter and Engelmann)
C: CT, Traditional

MEASURES

A. SBIQ gains at end of first grade
B. CAT G.E., Proportion above average (above 1.9) in reading and arithmetic
C. CAT G.E., Proportion below average (below 1.5) in reading and arithmetic

RESULTS

	E_1 (Ameliorative) vs. C	E_2 (Direct Verbal) vs. C
A. SBIQ gains	--	RPR = 2.34
B. Above 1.9 G.E. Reading	RPR = 2.08	RPR = 2.92
Above 1.9 G.E. Arithmetic	--	RPR = 2.50
C. Below 1.5 G.E. Reading	RPR = 6.00 (inverse RPR)	RPR = 4.80 (inverse RPR)
Below 1.5 G.E. Arithmetic	RPR = 3.05 (inverse RPR)	RPR = 2.60 (inverse RPR)
	(N = 3)	(N = 5)

Exhibit 94 **PT**

SOURCE

Markle, D.G. *The Development of the Bell System First Aid and Personal Safety Course: An Exercise in the Application of Empirical Methods to Instructional System Design*, Final Report, AIR E81-4/67-FR, American Institutes for Research, Palo Alto, California, April 1967. (58)

SUBJECTS

First aid, Red Cross First Aid Course

TREATMENTS

E: PT, Course designed in accord with instructional system design principles
C: CT, Traditional lecture/demonstration course

MEASURES

Scores, developer-designed criterion test based on content of standard Red Cross First Aid manual used in both treatments

RESULTS

Scores	*Time*	*Efficiency*	
RPR = 2.11 (scores)	1.33	2.81	
RPR = 4.74 (gains)	1.33	6.30	(N = 4)

PT **Exhibit 95a**

SOURCE

McMaster, J.C. *Cost-Effectiveness Analysis of Project IMPACT for the Philippines*, a report to the Australian Development Assistance Bureau for the Southeast Asia Ministers of Education Organization, INNOTECH, Manila, from School of Administrative Studies, Canberra College of Advanced Education, August 1978. (60)

SUBJECTS

Elementary curriculum, levels 1-6

TREATMENTS

All teaching done by PT (at grades 1-3 by fourth-, fifth-, and sixth-grade pupils) and by PL (at grades 4-6) under supervision of instructional supervisors (specially trained professional teachers). Pupil-instructional supervisor ratio ≃ 100-1.

E: Grades 1-3; PT, Cross-age programmed teaching by fourth-, fifth-, and sixth-graders. Note also, experience of programmed teachers of grade 1-3 pupils.
Grades 4-6: PL, Individual and group self-instruction partially programmed by learning material.
C: CT, Traditional instruction by professional teachers in comparable neighboring schools.

MEASURES

Average scores on SOUTELE (Survey of Outcomes of Elementary Education) tests (constructed and administered by Philippines Ministry of Education and Culture), costs, cost-effectiveness

RESULTS

SOUTELE scores	RPR = 1.09	
Costs	RPR = 2.00 (inverse RPR)	
Cost-effectiveness	RPR = 2.18	Total N = 2

Exhibit 95b **PT**

SOURCE

Mante, Rosetta F. *Multiple Outcomes and Multiple Client Perspectives in the Evaluation of Project IMPACT: A Two-Year Tracer Study*, Southeast Asian Ministers of Education Organization, Regional Center for Educational Innovations and Technology Project, September 1981. (57) (Follow-up of study reported in Exhibit 95a)

SUBJECTS

Elementary curriculum, levels 1-6

TREATMENTS

E: Grades 1-3: PT, Programmed Teaching by fourth-, fifth-, and sixth-graders. Grades 4-6: PL plus partially programmed individual and group self-instruction, and teaching experience.
C: CT, Traditional

MEASURES

Proportion of pupils giving favorable responses on self-concept and social attitude items

RESULTS

Differences favor E-group: RPR range = 2.22 to 3.56 (N = 7)
Difference favors C-group: RPR = 2.04 (N = 1)
(Total N = 8)

Exhibit 96

SOURCE

Mohan, M. *Peer Tutoring as a Technique for Teaching the Unmotivated*, State University College, Fredonia, New York, 1972. (ERIC Document Reproduction Service No. ED 061 154) (62)

SUBJECTS

Mathematics (second- and third-graders tutored by fifth- and sixth-graders); "Unmotivated" tutees and tutors (low 10% on teacher assessment and self-assessment sheets)

TREATMENTS

E: Pt, traditional plus semi-programmed cross-age tutoring (second- and third-graders tutored by fifth- and sixth-graders)
C: CT, traditional "teacher directed activities"

MEASURES

Scores on project-designed criterion test

RESULTS

Tutors: Significant differences but no RPR ≥ 2
Tutees: RPR = 3.14; (N = 1)

Exhibit 97 Pt

SOURCE

Parres, R.M. and H.R. Hoops, *Evaluation of the High Intensity Tutoring Center Program, 1971-72, The Second Year*, School District of the City of Highland Park, Michigan (Title I, ESEA), Wayne State University, Detroit, Michigan, (Hoops, H.R. Appendix I, Summary of Formal Data Analysis). (67)

Grey, B.B. "Performance Determined Instruction Model." In R. Bradfield, ed., *Operant Methods for Learning Disabilities*, Academic Therapy Publications, San Rafael, California, 1981. (38)

SUBJECTS

Reading, arithmetic (sixth-grade tutees, seventh- and eighth-grade tutors)

TREATMENTS

E: Pt, Traditional plus structured interclass tutoring, one or two semesters
C: CT, Gains predicted from prior school performances of pupils in E-group

MEASURES

Gains in reading and arithmetic on Wide Range Achievement Test

RESULTS

E vs. C: Reading, RPR range = 2.00 to 4.71 (N = 7)
Mathematics, RPR range = 2.07 to 2.38 (N = 3) (Total N = 10)

Exhibit 98

SOURCE

Ronshausen, N.L. "The Effect on Mathematics Achievement of Programmed Tutoring as a Method of Individualized, One-to-One Instruction," a paper presented at AERA annual meeting, Chicago, 1974. (75)

Ronhausen, H.L. "Programmed Tutoring: An Instructional Method for Primary School Mathematics," *Educational Technology*, January 1975, pp. 22-27. (74)

Hartwig, K.E. *Second Year Evaluation of the Early Childhood Mathematics Program*, Research Report No. 15, Series 1g 1972-June 1973. Sacramento City United School District, 1619 N Street, P.O. Box 2271, Sacramento, California 95810. (43)

SUBJECTS

First-grade mathematics

TREATMENTS

E: Pt, Traditional plus programmed tutoring (15 minutes daily) in beginning mathematics
C: CT, Traditional

MEASURES

Criterion test scores
Primary school mathematics (concepts and computation)

RESULTS

E vs. C: RPR = 2.00 (N = 1)

Exhibit 99 **Pt**

SOURCE

Rosenbaum, P.S. *Peer-Mediated Instruction*, Chapter IV. New York: Teachers College Press, 1973 (New York Telephone study: Employees English Language Class). (78)

SUBJECTS

Remedial English (reading)

TREATMENTS

E: Pt, Peer-Mediated instruction (PMI) using students as programmed tutors, individual pacing
C: CT, MIND program: 100 hours of instruction described as "instructor-controlled class pacing," utilizing MIND textbook and associated tapes

MEASURES

A: SAT and Nelson Tests, vocabulary gains, instructional time, and efficiency
B. Grade levels gained per hour of instruction
C. Proportion gaining one G.E. after 50 hours of instruction and after 100 hours of instruction

RESULTS

	Test	*Gains*	*Time (inverted RPR)*	*Efficiency*	
A.	SAT	RPR = 1.90	RPR = 2.17	RPR = 4.12	
	NELSON	RPR = 1.98		RPR = 4.30	(N = 3)

B. RPR = 2.57 (N = 1)
C: After 50 hours, RPR = 3.80; after 100 hours, RPR = 2.00 (N = 2)
(Total N = 6)

Pt **Exhibit 100**

SOURCE

Rosenbaum, P.S. *Peer-Mediated Instruction* (PMI), Chapter V. New York, Teachers College Press, 1973. (78)

SUBJECTS

Remedial reading (grades 7-12), vocabulary and comprehension

TREATMENTS

E: Pt, Traditional plus PMI (vocabulary 20 hrs., comprehension, 20 hrs.)
C: CT, Traditional

MEASURES

G.E. gains, Nelson Test (a) vocabulary, (b) comprehension

RESULTS

Vocabulary: RPR = 5.45; Comprehension: RPR = 8.05; Combined: RPR = 6.55 (N=3)

Exhibit 101

Pt

SOURCE

Rosenbaum, P.S. *The Brandeis PMI Reading Project*, Mid-Year Report. Teachers College, Columbia University, New York, April 1974. (76)

SUBJECTS

Remedial reading, grades 8-10

TREATMENTS

E: Pt, Traditional 2 hrs. per week plus peer-mediated instruction 3 hrs. per week
C: CT, Traditional 5 hrs. per week

MEASURES

California Achievement Test, G.E. gains, reading (Sept.-Dec.)
Number of classes showing loss or no gain

RESULTS

CAT gains: RPR = 4.06
Number of classes showing loss or no gain: RPR = 11.00 (inverse RPR) (N = 2)

Pt **Exhibit 102**

SOURCE

Rosenbaum, Peter S. *The Bushwick PMI Math Project*, Prepared for the Economic Development Council of New York, April 1974, The Peer-Mediated Instruction Project, Horace Mann-Lincoln Institute, Teachers College, Columbia University. (77)

SUBJECTS

High school math computation (remedial)

TREATMENTS

E: Pt, Peer-mediated instruction (PMI). Pairs of students alternate roles as tutors and learners in programmed tutoring situation. Traditional teaching two hours per week, PMI 3 hours per week.
C: CT, Traditional teaching 5 hours per week

MEASURES

MAT Intermediate, problem-solving subtest; grade equivalent scores

RESULTS

RPR = 3.00 (N = 1)

SOURCE

Snapp, M.; T. Oakland; and F.C. Williams. "A Study of Individualized Instruction by Using Elementary School Children as Tutors," *Journal of School Psychology*, 1972, vol. 10, no. 1, pp. 1-8. (93)

SUBJECTS

Reading, grades 1-3

TREATMENTS

E_1: Pt, Traditional plus programmed tutoring
E_2: Pt, Traditional plus programmed tutoring with reinforcement
C: Traditional

MEASURES

Gains, criterion test, word recognition; gains, MAT (reading)

RESULTS

E_1 vs. C: RPR = 2.20 (Criterion test): RPR = 4.32 (MAT reading)
E_2 vs. C: RPR = 2.53 (Criterion test)
E_1 vs. E_2: RPR = 2.73 (MAT, reading) (Total N=6)

PPT

Partially Programmed Teaching

Exhibits 105-120

PPT **Exhibit 105**

SOURCE

Bossone, R.M.; and L.Q. Troyka. *A Strategy for Coping with High School and College Remedial English Problems*, City University of New York, New York Graduate School and University Center, New York, 1976. (ERIC Document Reproduction Service No. ED 130 268) (5)

SUBJECTS

High school remedial English, essay writing

TREATMENTS

E: PBID, Correlated reading-writing materials, "highly structured" traditional teaching
C: CT, Traditional

MEASURES	**RESULTS**
Comparison of first and final essays: Proportion showing improvement	RPR = 2.07 (N = 1)
Proportion of pupils showing decline in performance: (inverse RPRs)	RPR range = 2.37 to 5.58 (N = 6)
	(Total N = 7)

SOURCE

Taylor, J.E.; E.R. Michaels; and M.F. Brennan. *The Concepts of Performance-Oriented Instruction Used in Developing the Experimental Volunteer Army Training Program* (HumRRO Tech. Rep. 72-7), Human Resources Research Organization, Alexandria, Virginia, March 1972. (94)

SUBJECTS

Military technical courses with performance objectives. Specific subjects are indicated in the titles of the exhibits listed below.

TREATMENTS

E: PBI, the amount and nature of the teaching, largely self-instructional practice and study, was directed by the instructor or by the instructor and student in conference, on the basis of the student's performance on criterion test items (derived from the relevant instructional objectives and administered during the training process). As described by the authors: "...performance training maximizing hands-on experience and practice, and placing verbal presentations in relevant context...techniques by which the trainee can learn at his own pace, as much as feasible...instructor roles of demonstrating skills, organizing skill practice, and checking out all individuals at the training site to provide immediate feedback on skill acquisition." Partially programmed, as a minimum by specifying instructional objectives.
C: CT, "A lecture-demonstration-practice instructional paradigm...lock-step instruction...An instructor role of mainly presenting information."

It should be noted that the two treatments differ also in at least one respect not indicated here. All of the examples of PBI included in Taylor's report are clearly also examples of performance-based instructional design (PBID). PBID procedure, like PBI procedures, utilizes information derived from comparisons of pupil performance and objectives, but uses it for a different purpose — as the primary basis for the development or improvement of instructional and administrative procedures.

The developmental history of the conventional control procedures in Taylor's examples is not specified, but it most certainly differs from that described as PBID. The results reported below for evaluations of the effects of PBID suggest that the presence or absence of a PBID history can significantly affect the results achieved by any teaching technique.

MEASURES

Proportion of students passing (70% criterion) or failing on criterion performance tests or sub-tests, using an absolute go/no-go criterion for test items.

A. E/C ratio of proportions passing all requirements on terminal criterion tests
B. E/C ratio of proportions failing all requirements (Inverted R)
C. E/C ratio of proportions passing particular requirements (sub-tests)
D. E/C ratio of proportions failing particular requirements (Inverted R)

(continued on next page)

Exhibits 106-120 Continued

RESULTS

Exhibits (Course Names)	A RPRs	B (Inverse RPRs)	C RPRs	(N)	D (Inverse RPRs)	(N)
106 BCT First Aid	94.00***	—	12.00-20.00	3	2.97-5.81	3
107 BCT Chem. Biol. Radiol.	10.25***	—	2.69-3.56	2	2.27-4.57	4
108 BCT Land Navigation	5.86***	—	3.29	2	2.00-9.00	5
109 BCT M-16 Maintenance	2.11***	—	2.19	1	2.00-2.13	3
110 BCT Guard	—	2.20**	—	0	2.20-9.00	4
111 BCT 1. Tactical Trng.	—	—	—	0	3.75	1
112 BCT Drill & Ceremonies	—	—	—	0	4.40-5.00	2
113 AIT .45 Cal. Pistol	—	—	—	0	2.25	1
114 AIT Grenade Launchers	—	19.50***	—	0	4.00-37.00	3
115 AIT M-72 LAW	82.00***	5.50***	84.00	1	5.25-14.00	2
116 AIT M-60 Machine Gun	3.40***	—	2.00-6.36	3	2.17-2.97	3
117 AIT Night Vision Device	—	—	17.00	1	3.00	1
118 AIT Landmine Warfare	6.30***	—	—	0	2.84	1
119 AIT Communications	2.60***	—	—	0	2.86-7.42	2
120 AIT Land Navigation	3.38***	2.72***	2.26		2.50-4.64	4

*E/C Pass-ratio = 9%/0%, significant at .001 level

**p < .003

***p < .001

PBID

Performance-Based Instructional Design

Exhibits 121-125

PBID **Exhibit 121**

SOURCE

Caro, P.W.; R.N. Isley; and O.B. Jolley. *The Captive Helicopter as a Training Device: Experimental Evaluation of a Concept* (HumRRO Tech. Rep. 68-9), Human Resources Research Organization, Alexandria, Virginia, June 1968. (11)

SUBJECTS

Helicopter flight training

TREATMENTS

E: PBID, Traditional 12-week primary flight training course plus behavior-shaping course in captive helicopter device
C: CT, Traditional course only

MEASURES

Proportion of eliminations due to flying deficiencies in subsequent training

RESULTS

RPR = 2.98 (inverse RPR); (N = 1)

Exhibit 122 **PBID**

SOURCE

Gebhard, R.M. *Development of a Training Program and Job Aids for Maintenance of Electronic Communication Equipment* (HumRRO Tech. Rep. 70-19), Human Resources Research Organization, Alexandria, Virginia, December 1970. (36)

SUBJECTS

Maintenance of electronic communication equipment

TREATMENTS

E: PBID, Traditional course designed in accord with instructional systems design principles (semi-programmed)
C: CT, Standard (traditional) course

MEASURES

Instructional time: Time required for course (11 vs. 25 weeks); scores (not significantly different on four project-constructed job performance tests); efficiency.

RESULTS

Scores	*Time*	*Efficiency*	
RPR = 1.00	2.27 (inverse RPR)	2.27	N = 2

Exhibit 123

SOURCE

McKnight, A.J. and P.J. Butler. *Identification of Electronics Maintenance Training Requirements: Development and Evaluation of an Experimental Ordnance Radar Repair Course* (HumRRO Research Report No. 15), Human Resources Research Organization, Alexandria, Virginia, 1964. (59)

SUBJECTS

Ordnance radar repair

TREATMENTS

E: PBID, Traditional lecture/lab refined by ISD technology (22 week course)
C: CT, Traditional lecture/lab (37 week course)

MEASURES		RESULTS	
	Criterion Test Scores	*Time*	*Efficiency*
Shop Troubleshooting	RPR = 2.18	1.22 (inverse RPR)	2.66
Systems Troubleshooting	RPR = 2.29	1.33 (inverse RPR)	3.05

N = 4

Exhibit 124 **PBID**

SOURCE

Melaragno, R.J. *Influence of the Tutorial Community Project on Reading Achievement at Pacoima Elementary School*, Tutorial Community Project, Pacoima, CA, 1973. (61)

SUBJECTS

Reading, grades 1-3

TREATMENTS

E: PBID, Performance based refinements of technique used in C, same subjects and levels as controls
C: CT, Traditional, plus traditional tutoring

MEASURES

Proportion of pupils above two cutoff scores, namely, 50th or 75th percentile scores for standardization groups of the following tests: Stanford Achievement Test, Reading Cooperative Primary Reading Test

RESULTS

Stanford: RPRs = 2.00; 4.67 (N = 2)
Cooperative: Range of RPRs: 2.00 to 12.17 (N = 13)
(Total N = 15)

PBID **Exhibit 125**

SOURCE

Sherrill, J.L. *Competency Based Testing in a Communicative Arts Task*, Directorate of Training Development, U.S. Army Administration Center, Fort Benjamin Harrison, June 1978. (86) (draft copy).

SUBJECTS

Military court reporting, performance

TREATMENTS

E: PBID, A relatively traditional course as taught in the 4th, 17th, and 18th versions. (Continuous revisions based on analyses of student performance.)
C: CT, The "same" course as taught in the first (pre-refinement) version

MEASURES

Proportion scoring below median score of first class taught; criterion-based performance test

RESULTS

For 4th, 17th, 8th time course was taught: RPRs (inverse) = 2.20, 2.56, 6.25, respectively (N = 3)

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